



NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

**MARINE CORPS EXPEDITIONARY RIFLE PLATOON
ENERGY BURDEN**

by

Thomas A. Atkinson

December 2014

Thesis Co-Advisors:

Richard Millar
Warren Vaneman

Approved for public release; distribution is unlimited

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE			<i>Form Approved OMB No. 0704-0188</i>	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE December 2014	3. REPORT TYPE AND DATES COVERED Master's Thesis	
4. TITLE AND SUBTITLE MARINE CORPS EXPEDITIONARY RIFLE PLATOON ENERGY BURDEN			5. FUNDING NUMBERS	
6. AUTHOR Thomas A. Atkinson			8. PERFORMING ORGANIZATION REPORT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A				
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government. IRB protocol number ____N/A____.				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited			12b. DISTRIBUTION CODE A	
13. ABSTRACT (maximum 200 words) In 2009, the Commandant of the Marine Corps declared energy a top priority and created the U.S. Marine Corps (USMC) Expeditionary Energy Office to develop an energy strategy to reduce and optimize energy usage throughout the Marine Corps. This thesis examines the operational tasks and capabilities that drive the current USMC rifle platoon's energy burdens using an Expeditionary Warrior 2012 war-game scenario. The primary conclusion of the research is that increasing the platoon's ability to carry supplies and developing standardized, rechargeable batteries offers the USMC opportunities to reduce energy at the platoon level. This thesis recommends that the USMC should investigate the use of robotic transport systems and use of unmanned aerial vehicles to reduce the number of sustainment flights required of large aircraft. It also recommends further research should be conducted to calculate the energy usage at the company level, analyzing robotic solutions and standardized batteries to reduce energy at the platoon level and conducting analysis for water reduction.				
14. SUBJECT TERMS Marine rifle platoon, Marine expeditionary energy, Marine rifle platoon mission essential tasks. expeditionary energy, water and waste (E2W2)			15. NUMBER OF PAGES 109	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UU	

THIS PAGE INTENTIONALLY LEFT BLANK

Approved for public release; distribution is unlimited

MARINE CORPS EXPEDITIONARY RIFLE PLATOON ENERGY BURDEN

Thomas A. Atkinson
Lieutenant Colonel, United States Marine Corps
B.A., University of Washington, 1996

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN ENGINEERING SYSTEMS

from the

**NAVAL POSTGRADUATE SCHOOL
December 2014**

Author: Thomas A. Atkinson

Approved by: Richard Millar
Thesis Co-Advisor

Warren Vaneman
Thesis Co-Advisor

Clifford Whitcomb
Chair, Department of Systems Engineering

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

In 2009, the Commandant of the Marine Corps declared energy a top priority and created the U.S. Marine Corps (USMC) Expeditionary Energy Office to develop an energy strategy to reduce and optimize energy usage throughout the Marine Corps. This thesis examines the operational tasks and capabilities that drive the current USMC rifle platoon's energy burdens using an Expeditionary Warrior 2012 war-game scenario. The primary conclusion of the research is that increasing the platoon's ability to carry supplies and developing standardized, rechargeable batteries offers the USMC opportunities to reduce energy at the platoon level. This thesis recommends that the USMC should investigate the use of robotic transport systems and use of unmanned aerial vehicles to reduce the number of sustainment flights required of large aircraft. It also recommends further research should be conducted to calculate the energy usage at the company level, analyzing robotic solutions and standardized batteries to reduce energy at the platoon level and conducting analysis for water reduction.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

EXECUTIVE SUMMARY	XV
I. INTRODUCTION.....	1
A. PURPOSE.....	1
B. BACKGROUND	1
C. RESEARCH QUESTIONS.....	2
D. RESEARCH METHODOLOGY	2
E. THE ORGANIZATION OF THIS STUDY	3
II. BACKGROUND	5
A. THE U.S. MARINE CORPS E2W2 REDUCTION STRATEGY.....	5
B. THE STRUCTURE AND EQUIPMENT OF A U.S. MARINE RIFLE PLATOON.....	8
C. MARINE RIFLE-PLATOON CORE ACTIVITIES	11
D. CORE-ACTIVITIES SUSTAINMENT REQUIREMENTS.....	12
E. U.S. MARINE RIFLE PLATOON MODELED IN THE EW12 WAR- GAME	13
F. USING FUNCTIONAL ANALYSIS TO DOCUMENT THE ENERGY BURDEN.....	14
G. SUMMARY	14
III. METHODOLOGY	17
A. SCENARIO DESCRIPTION.....	17
1. Overview	17
2. U.S. Marine Rifle Platoon Situation and Mission	19
3. Planning Factors	19
B. USMC EQUIPMENT MODELED	20
C. PLANNING ASSUMPTIONS	21
D. THE ENERGY MODEL.....	21
1. Battery Model.....	22
a. <i>USMC Rifle Company Table of Organization and Equipment</i>	22
b. <i>E2O MEB 2024 Equipment Calculations</i>	26
c. <i>Building the Battery Model.....</i>	26
2. Fuel Model	26
a. <i>Step 1: The Flight to MRP AOR</i>	26
b. <i>Step 2: Sustainment Flights.....</i>	27
c. <i>Step 3: MEDEVAC Missions.....</i>	27
d. <i>Step 4: Flight from AOR.....</i>	30
E. SUMMARY	30
IV. DATA ANALYSIS.....	31
A. BATTERY MODEL DATA PRESENTATION	31
B. FUEL-MODEL DATA PRESENTATION.....	34

1.	The Flight to the AOR	34
a.	Option 1: MV-22	34
b.	Option 2: CH-53E	35
c.	Analysis.....	35
2.	Sustainment Flights of the Platoon.....	35
a.	Option 1, MV-22.....	36
b.	Option 2, CH-53E	36
c.	Option 3, KC-130.....	36
d.	Analysis.....	36
3.	Medical Evacuation Missions.....	37
a.	Option 1, MV-22, Unescorted.....	37
b.	Option 2, MV-22, Escorted	37
c.	Option 3, CH-53E, Unescorted.....	37
d.	Option 4, CH-53, Escorted.....	37
e.	Analysis.....	38
4.	The Flight from the AOR.....	38
a.	Option 1: MV-22	38
b.	Option 2: CH-53E	38
c.	Analysis.....	38
C.	ANALYSIS	39
D.	SUMMARY	39
V.	CONCLUSIONS AND RECOMMENDATIONS.....	41
A.	FACTORS RESPONSIBLE FOR THE USMC RIFLE-PLATOON E2W2 BURDEN.....	41
B.	THE E2W2 BUDGET FOR THESE TASKS.....	42
C.	RECOMMENDATIONS.....	42
1.	Investigate Robotic Transport.....	42
2.	Unmanned, Aerial Systems	42
3.	Standardized, Rechargeable Batteries	43
D.	RECOMMENDATIONS FOR FURTHER RESEARCH	43
APPENDIX.	U.S. MARINE CORPS RIFLE PLATOON MISSION ESSENTIAL TASKS (FROM USMC 2012B, 1ST PLATOON TAB).....	45
LIST OF REFERENCES		85
INITIAL DISTRIBUTION LIST		89

LIST OF FIGURES

Figure 1.	EW12 Concept of Operations (from USMC 2012a, 9).....	18
Figure 2.	Typical Platoon Flashlight and NVGs	33

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

Table 1.	Rifle Platoon Organic Weapons.....	10
Table 2.	Major Energy-Consuming Systems in a Rifle Platoon (from USMC 2013b)	10
Table 3.	Weight and Days of Supply for Platoon Operations (from Bain 2005).....	20
Table 4.	Marine Aircraft Comparison (from Department of Defense 2006)	21
Table 5.	Billet Organization of a Marine Rifle Company (from USMC 2013b, 10).....	24
Table 6.	Equipment Organization of a Marine Rifle Company (from USMC 2013b, 19)	25
Table 7.	Combat Intensity for the Rifle Platoon’s EW12 Mission	28
Table 8.	Estimate Casualty Range for Ground Forces.....	28
Table 9.	Casualties per Sortie	29
Table 10.	Total Aviation Casualties.....	30
Table 11.	Expeditionary Energy Model Showing Rifle-Platoon Equipment Only.....	32

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

ACE	Air Combat Element
AOR	Area of responsibility
APOD	Air point of debarkation
ATF	Amphibious task force
CBRNE	Chemical, biological, radiological, nuclear environment
CE	Command Element
CJTF	Coalition joint task force
CMC	Commandant of the Marine Corps
DOD	Department of Defense
DOS	Day of supply
E2O	Expeditionary Energy Office
E2W2	Expeditionary energy, water, and waste
EW12	Expeditionary Warrior 2012
FSM	Free Savanna Movement
GCE	Ground Combat Element
ICD	Initial Capabilities Document
INCOSE	International Council on Systems Engineering
km	Kilometer
LCE	Logistics Combat Element
MAGTF	Marine Air Ground Task Force
MEB	Marine Expeditionary Brigade
MEDEVAC	Medical evacuation
MEF	Marine Expeditionary Force
MET	Mission-essential task
METT	Mission, Enemy, Terrain and Troops
MEU	Marine Expeditionary Unit
MRP	Marine Rifle Platoon
NVG	Night Vision Goggles
SAW	Squad automatic weapon
SPOD	Seaport point of debarkation

TAMCN	Table-of-allowance material-control number
TO&E	Table of organization and equipment
UAS	Unmanned Aerial System
U.N.	United Nations
U.S.	United States
USMC	United States Marine Corps
WAF	West African Federation

EXECUTIVE SUMMARY

This thesis examines the energy burden of the United States Marine Corps Rifle Platoon using a counterinsurgency scenario from the Expeditionary Warrior 2012 war-game. This summary gives an overview of the Commandant of the Marine Corps energy reduction goals and the conclusions and recommendations from the two primary research questions. The thesis was designed as the first of several efforts to identify ways to reduce the Marine Corps dependence on energy.

In 2009, the Commandant of the Marine Corps declared energy a top priority and created the U.S. Marine Corps (USMC) Expeditionary Energy Office to develop an energy strategy to reduce and optimize energy usage throughout the Marine Corps. Two near-term goals were defined as a result: first, embed expeditionary energy into the USMC ethos and lead and manage expeditionary energy performance (HQ USMC n.d., 21). Second, mandated that commanders and program managers “track and manage energy and water demand levels and overall usage” (HQ USMC n.d., 21) for all equipment and systems by 2015.

This thesis examines the operational tasks and capabilities that drive the current USMC rifle platoon’s energy burdens and answers two primary research questions:

- What specific tasks and operational activities, or capabilities are responsible for the USMC rifle-platoon energy burden?
- What is the energy budget?

The rifle platoon has 12 mission-essential tasks. Of these 12, conducting combat service support and command and control are the two that provide opportunities for the US Marine Corps to reduce energy. Conducting combat service support operations requires the platoon to be transported to and from the area of responsibility, conducting medical evacuation, and sustaining and resupplying the platoon all of which require energy. Command and control requires communication equipment that utilizes batteries, of which the platoon uses ten different battery types, especially non-rechargeable AA batteries.

For the two-week counterinsurgency operation, the platoon would require about 11,700 gallons of fuel for sustainment operations, based on the lowest consumption option from the different USMC aircraft. Placing the aircraft closer to the platoon would decrease fuel consumption, but a more practical way to reduce fuel consumption would be to reduce the number of sustainment flights by increasing the each Marine's ability to carry supplies or increasing the platoon's ability to be self-sustaining. To conduct command and control, the platoon would need to carry as many as 5,500 single-use batteries and recharge its reusable batteries 775 times. The platoon requires 4,000 lithium/manganese-dioxide batteries, the primary kind used, every 14 days.

Based on the analysis, three recommendations are made:

- The platoon is limited to three days of supply (DOS) based on what an individual can carry, which requires logistics runs every two to three days. The Marine Corps should study the use of fuel-efficient, robotic alternative platforms to carry supplies while the platoon is patrolling, to reduce the requirement for logistics and sustainment flights.
- The Marine Corps should continue to explore fuel-efficient unmanned aerial systems (UASs) technologies for sustainment flights that reduce reliance on MEU aircraft assets that are of already low density and high demand. If increasing the DOS is impossible, UASs like the Kaman K-MAX, which is already used by the Marine Corps, could deliver supplies at reduced fuel levels. In this scenario, two K-MAX UASs would deliver the required 10,977 pounds of supplies at a fuel consumption of only 83 gallons per hour, and require no escort. This would be a fuel savings of over 6,000 gallons over a CH-53E with AH-1W escort (Kaman K-MAX n.d.).
- The Marine Corps should look at developing standardized, rechargeable batteries that can be used in all command-and-control systems and other equipment. Any robotic device fielded to carry supplies should also be able to recharge batteries, thus reducing the burden the platoon has to carry, keeping waste to a minimum, and providing a ready, reliable source of energy.

The results of this analysis suggests further research should be conducted to calculate the energy usage at the company level, analyze robotic solutions and standardized batteries to reduce energy at the platoon level and conducting analysis for water reduction.

ACKNOWLEDGMENTS

I would like to thank Dr. Richard Millar and Dr. Warren Vaneman for their advice and encouragement in helping me conduct the research, and for the guidance they provided while writing this thesis. I would like to thank the Expeditionary Energy Office for the literature and energy study data it provided.

THIS PAGE INTENTIONALLY LEFT BLANK

I. INTRODUCTION

A. PURPOSE

This research identifies the operational tasks and capabilities driving the United States Marine Corps (USMC) rifle platoon's expeditionary energy burdens. Background information on the U.S. Marine Corps vision to reduce energy, water and waste across the Marine Air Ground Task Force (MAGTF) is presented, as well as the capabilities of a Marine rifle platoon, its core activities, and platoon energy sustainment requirements. This thesis assesses current Marine rifle-platoon functional activities that drive energy requirements to identify ways to become "leaner, lighter, and less energy-intensive" (Headquarters U.S. Marine Corps [HQ USMC] 2008, 23), which will "allow the MAGTF the ability to conduct operations in the most austere environments" (HQ USMC 2010, 37). Research findings are presented and recommendations for energy reductions are made.

B. BACKGROUND

The United States Marine Corps is the nation's readiness force, built around rapid, short-notice deployments from amphibious ships or by any means necessary to accomplish its mission. The MAGTF concept consisting of four elements: the command element (CE), the ground combat element (GCE), the air combat element (ACE) and logistics combat element (LCE) that can be scaled and tailored to any mission. Historically, the MAGTF is mobile, expeditionary, and self-sustaining. In the past decade of fighting in Iraq and Afghanistan, however, the Marine Corps has grown heavier and more reliant on a long logistics trail. Dependency on this vulnerable trail means that fighting capability must be diverted from the front to defend the rear.

Recognizing how the MAGTF's increasing dependency on logistics is compromising warfighting capability (and operating budget), the Commandant of the Marine Corps (CMC) established the Expeditionary Energy Office (E2O) to "analyze, develop, and direct the Marine Corps' energy strategy in order to optimize expeditionary capabilities across all warfighting functions" (HQ USMC n.d., 5). Two near-term goals

were defined as a result: first, embed expeditionary energy into the USMC ethos and lead and manage expeditionary energy performance (HQ USMC n.d., 21). Second, mandate that commanders and program managers “track and manage energy and water demand levels and overall usage” (HQ USMC n.d., 21) for all equipment and systems by 2015.

To illustrate how the Marine Corps has become energy dependent, typical planning for daily fuel consumption for a Marine expeditionary brigade is divided 78 percent to the ACE and the remaining 22 percent to the rest of the MAGFT. However, actual fuel consumption from Afghanistan shows that “75% was consumed by ‘ground forces,’ which includes use by vehicles, generators, and other sustainment equipment” (HQ USMC n.d., 70–71), with the ACE consuming the remaining 25 percent. To operate from austere locations and maintain its expeditionary edge, Marine Corps ground forces must reduce their need for energy, water, and supplies (HQ USMC 2010, 39). The Marine rifle platoon is an infantry unit of 40–45 Marines. As a component of the GCE, the platoon contributes to the GCE’s energy consumption.

C. RESEARCH QUESTIONS

The primary research questions pertinent to this research are as follows:

- What specific tasks and operational activities or capabilities are attributable to the Marine Corps rifle platoon’s energy burden?
- What is the energy budget?

To answer the primary research questions, it is necessary to pose the following subsidiary questions:

- What is the USMC energy, water, and waste-reduction strategy (E2W2) reduction strategy?
- What is the structure of a Marine rifle platoon and how is it equipped?
- What are the core activities of a rifle platoon?
- What logistical requirements are needed to sustain the core activities?

D. RESEARCH METHODOLOGY

Research began with a literature review, including USMC policy, doctrine and structure; books, magazines, and newspaper articles; and online resources. As follow-up,

interviews were conducted with key stakeholders concerning the USMC rifle-platoon mission, activities, and logistics.

E. THE ORGANIZATION OF THIS STUDY

This thesis is organized into the following chapters:

Chapter II of this thesis surveys the USMC expeditionary energy, water, and waste-reduction strategy (E2W2) and describes the equipment and core activities of a Marine rifle platoon. The Expeditionary Warrior 2012 war-game is introduced as a model for identifying platoon energy consumption, and the chapter concludes by examining how functional analysis may help identify opportunities to reduce consumption.

Chapter III explains how the research questions were selected and analyzes a Marine rifle-platoon mission scenario, using the Expeditionary Warrior 2012 war-game to calculate critical energy requirements.

Chapter IV analyzes gathered data and Chapter V presents conclusions, including areas for follow-on research to identify potential energy reducing solutions.

THIS PAGE INTENTIONALLY LEFT BLANK

II. BACKGROUND

This chapter discusses the USMC's expeditionary energy, water and waste (E2W2) reduction strategy and describes the structure and equipment of rifle platoons, the focus of this research. The Expeditionary Warrior 2012 war-game is introduced as a model for analyzing energy consumption, and the chapter concludes by examining how functional analysis of energy burdens can identify opportunities for saving energy at the platoon level.

A. THE U.S. MARINE CORPS E2W2 REDUCTION STRATEGY

The USMC is normally organized by task into Marine Air Ground Task Forces (MAGTFs). MAGTFs comprise a command element (CE), a ground element (GE), and aviation and logistics elements. MAGTFs fulfill a variety of missions, from amphibious assault to peacekeeping, and can operate alone or with a joint force (Estes 1988, 68–70). The MAGTFs can also make forcible entry from the sea, through amphibious operations that are the responsibility of the Marine Corps under Title 10 (10 U.S. Code 5063 2011). The hallmark of the MAGTFs is their ability to act as a self-sustaining, mobile unit able to “operate for extended periods as an expeditionary force.” The larger MAGTFs have more sustainment capability, which allows longer periods of self-sustainment (HQ USMC 2013, 16).

The four types of MAGTF are the Marine Expeditionary Force (MEF), the Marine Expeditionary Brigade (MEB), the Marine Expeditionary Unit (MEU) and Special-Purpose MAGTFs. On any given day, the Marine Corps has two forward-deployed MEUs that are embarked on U.S. Navy amphibious vessels. MEUs provide the U.S. president and combatant commanders a forward-deployed expeditionary unit wielding the full spectrum of military operations from the sea. A Colonel commands the MEU and is responsible for the training, certification, and warfighting capability of the integrated air, ground, and logistics elements, working as a lethal and sustainable force (HQ USMC 2013, 14–15).

Since September 11, 2001, the USMC has been fighting in Iraq and Afghanistan. The challenge of a long, land-based conflict against an enemy that is continuously adapting to become more lethal has resulted in USMC and MAGTF equipments becoming heavier, due to the need for added armor protection, new equipment that is survivable in the face of improvised, explosive devices, and increased dependence on command, control, communications, computers, and intelligence systems and technology (Marine Corps Combat Development Command [MCCDC] 2012, 1). Though this improved equipment has made the Marine Corps more effective in Iraq and Afghanistan, it has eroded the expeditionary nature of MEUs and significantly increased their energy dependency. Like the USMC, during the twelve years the Army has been conducting stability and sustainment operations in the Middle East, it has become obsessed with protecting its forces from improvised explosive devices and other attacks, while mobility and agility logistics have taken second place (Erwin 2013).

According to the USMC document, “Expeditionary Energy, Water and Waste Initial Capabilities,” “over 70 percent of the logistics required to sustain Marine Corps expeditionary forces ashore is liquid, fuel and water” (MCCDC 2012, 1). Energy dependency has created a critical vulnerability, as operational units are forced to defend and protect the long supply lines they rely on, which diverts manpower and erodes warfighting capability (HQ USMC n.d., 3). This conundrum has not been lost on the enemy. The supply chain is a soft target whose breach can disrupt operations and put Marine lives severely at risk (HQ USMC 2010, 36).

Recognizing this problem, in 2009 the Commandant of the Marine Corps declared energy a top priority and created the USMC Expeditionary Energy Office (E2O), whose mission it is to “analyze, develop, and direct the Marine Corps’ energy strategy in order to optimize expeditionary capabilities across all warfighting functions” (HQ USMC n.d., 5). Two near-term goals were established shortly thereafter:

- Embed expeditionary energy into the USMC ethos.
- Lead and manage expeditionary energy performance (HQ USMC n.d., 21).

The USMC expeditionary-energy strategy expresses a vision for how the USMC can return to its expeditionary nature. Key to the strategy's success is more efficient and effective use of energy and instilling the concept that energy conservation is the same as combat effectiveness. Linking energy conservation and combat effectiveness will allow the Marine Corps to achieve five of the CMC's operational objectives:

- A lighter, faster, more maneuverable, and more resilient maneuver force
- Increased ability for the MAGTF to operate in austere environments
- Reduced operational risk through reduced logistics footprint and threat exposure
- Increased autonomy and tactical mobility, particularly at the company level and below
- Increased MAGTF agility, reach, endurance, freedom of action, and operational tempo (MCCDC 2012, 3).

The strategy seeks to return the USMC and MAGTF to its self-sufficient, expeditionary roots by reducing dependency on energy. The USMC seeks a “50% reduction in energy consumption, from 8 gallons of fuel/Marine/day to 4 gallons of fuel/Marine/day by 2025” (Bulanow, Tabler, and Charchan 2011, 6).

The ground combat element, which provides the MAGTF with forcible-entry capability from the sea, accounts for three-fourths of the energy consumed by the MAGTF. Heavier vehicles and the power-generating equipment needed to run computers and command-and-control devices also drive a heavier force overall (HQ USMC n.d., 70–71). Reducing the need for energy, batteries, and other sustainment items helps the battlefield commander meet the challenge of sustaining and maintaining his forces. Furthermore, reducing energy requirements allows the GCE to move faster, operate from austere locations, and become less attached to long supply chains (HQ USMC 2010, 37).

A fundamental unit within the GCE is the Marine rifle platoon (MRP). The MRP is an infantry unit, which is the core component of the GCE. Each MRP consists of 40–45 Marines and requires energy-consuming equipment to function.

B. THE STRUCTURE AND EQUIPMENT OF A U.S. MARINE RIFLE PLATOON

The infantry and other ground elements of the Marine Corps reside in divisions, whose purpose is to provide “ground amphibious forcible-entry capability to an amphibious task force (ATF) and conduct subsequent land operations in any operational environment” (HQ USMC 1998, 4-1). There are three active-duty divisions: the First Marine Division in Camp Pendleton, California; the Second Marine Division in Camp Lejeune, North Carolina; and Third Marine Division in Camp Butler, Japan. A reserve group, the Fourth Marine Division, is headquartered in New Orleans, Louisiana. The threefold structure of infantry units is consistent with Marine Corps organization overall, from regiments to fire teams.

Each Marine division contains three infantry regiments, the arm that conducts independent and sustained close-combat operations. The primary mission of the infantry regiment is that shared by all subordinate units: “to locate, close with, and destroy the enemy by fire and maneuver or to repel his assault by fire and close combat” (HQ USMC 1998, 4-3, 4-4). A regiment has three infantry battalions and a headquarters company. The battalion is the regiment’s muscle, providing combat power for the regiment to accomplish its mission. Like a regiment, an infantry battalion has three rifle companies and a headquarters and support company; a weapons company provides the battalion with combined arms capability, while the rifle companies provide a basic maneuvering element. When a battalion is assigned to an MEU, it becomes a battalion landing team (HQ USMC 1998, 4-8).

A Marine rifle company is composed of three rifle platoons and a weapons platoon. The weapons platoon provides fire support from its assault, 60-millimeter mortar, and machine-gun sections. These elements reinforce the company’s three rifle platoons through the deployment of squads and teams from the various sections. The flexibility allows the Marine company to serve as the main maneuver element of the battalion and operate independently for short durations (HQ USMC 1978, 2-3).

Rifle companies share the mission of the regiment, as quoted above (United States Marine Corps [USMC] 2013b, 2). The company's three main tasks, which it accomplishes through its three rifle and one weapons platoon are as follows:

- Plan, coordinate, and direct the employment of rifle platoons and detachments to conduct fire and maneuver.
- Plan, coordinate, and direct the employment of weapons platoon to provide organic direct and indirect fires in support of the company's scheme of maneuver.
- Plan, coordinate, and conduct ground combat operations and type operations, as directed, across the spectrum of war in any expeditionary environment (USMC 2013b, 2).

The rifle platoon is the rifle company's basic maneuver element. On the attack, the platoon moves to close with and destroy the enemy; on the defense, it defends terrain and denies access (HQ USMC 1978, 1-2). The rifle platoon consists of 41 Marines, led by a lieutenant who is responsible for every aspect of the group, from training to battlefield performance. The platoon commander is assisted by a sergeant, usually a staff sergeant, and the two constitute the platoon's headquarters, directing the rifle squads in accomplishing mission tasks. Each squad consists of 13 Marines. The squad leader is responsible for three fire teams, the lowest element in the platoon, comprising four Marines and, like higher echelons, formulated around the combined-arms concept (HQ USMC 2002, 1-1).

The weapons organic to the rifle squad are the M-16 rifle with bayonet knife—with or without a 40-millimeter, M-203 grenade launcher—and the squad automatic weapon (SAW) and combat knife. The squad leader, assistant automatic rifleman and rifleman carry the M-16 with bayonet knife, while the fire-team leader carries the M-16 with M-203 and the automatic rifleman carries the SAW (HQ USMC 2002, 1-1), as shown in Table 1. These three weapons provide the combined arms capability to conduct maneuver warfare at the small unit level, Marine rifle squads and fire teams.

TAMCN	NOMENCLATURE	Number / MRP
E14422M	RIFLE,5.56 MILLIMETER—M16A4	23
E08927M	RIFLE,5.56 MILLIMETER—M16A4 WITH LAUNCHER, GRENADE—M203A2	9
E09607M	MACHINE GUN,5.56 MILLIMETER—M249	9

Table 1. Rifle Platoon Organic Weapons

In addition to its organic weapons, the rifle platoon uses other equipment to execute its mission, ranging from command-and-control devices such as radios and navigation aids to systems that allow the platoon to operate in any light and strike targets from afar. The major energy-consuming systems of a rifle platoon are listed in Table 2.

TAMCN	NOMENCLATURE	Number/ MRP
A01187G	RADIO SET—AN/PRC-153(V)1	40
A01297G	RECEIVER-TRANSMITTER—AN/PRC-152(V)1(C	6
A12607G	RECEIVER, RADIO NAVI—AN/PSN-13(B)	1
B04722E	DEMOLITION SET, EXPL	1
C00042E	VIEWING SET, INFRARED—NH11	1
C00742E	FLASHLIGHT—14032	41
E00087G	NIGHT VISION DEVICE—AN/PVS-24A	9
E00587G	ILLUMINATOR, INFRARED—AN/PEQ-16B	41
E09567B	BORE LIGHT SYSTEM, LA—LBS-300-A2	3
E11542B	NIGHT VISION DEVICE—AN/PVS14	41
E11607G	NIGHT VISION SIGHT—AN/PVS17C	9
E17797B	SIGHT, GRENADE LAUNC—AN/PSQ18A	9
E17987G	ILLUMINATOR, INFRARE—AN/PEQ-15	9
A12607GJ	NAVIGATION SET, SATE—AN/PSN-13(A)	1
E00547GA	RANGE FINDER, LASER—AN/PEQ-13	1

Table 2. Major Energy-Consuming Systems in a Rifle Platoon
(from USMC 2013b)

C. MARINE RIFLE-PLATOON CORE ACTIVITIES

A Marine rifle platoon has 12 mission-essential tasks (METs), which require careful planning and a dedicated year of training before the platoon is certified as ready to deploy. Within the METs, there are 58 events, or subtasks, that ensure the platoon has mastered the full range of activities in a particular MET. Some METs, like training, have as few as one event, while the maneuver MET, perhaps the platoon's most important mission-essential task, lists 25 events. The METs and their events are summarized below.

- Scout sniper: employs a sniper-control center and conducts operations
- Anti-armor: provides offensive and defensive fire and conducts motorized operations
- Assault: focuses on the platoon's providing direct fire, occupying firing positions, and providing mobility and counter-mobility
- Command and control: deals with planning, preparing for combat, integrating enablers, and executing command and control during the mission
- Combat service support: assesses the platoon's ability to conduct tactical logistics
- Force protection: conducts force protection, operating in a chemical, biological, radiological, nuclear environment (CBRNE), operating entry and traffic-control points
- Fire Support: integrates fires to support the platoon's scheme of maneuver
- Intelligence: collects intelligence and exploits intelligence at a tactical site
- Maneuver: contains the most events, which include conducting ground and airborne attacks, passage of lines, operations in the assembly area, detainee and MEDEVAC operations, and a variety of patrolling operations
- Machine guns: provides offensive and defensive fires, occupies firing positions, and conducts motorized operations
- Mortars employment: covers mortars, from providing indirect fires to employing mortars on standard and special missions
- Training: assesses the platoon's ability to develop a training strategy that covers all the MET list areas

Details of platoon METs are found in the appendix.

D. CORE-ACTIVITIES SUSTAINMENT REQUIREMENTS

Of the 12 mission-essential tasks, nine involve tactical logistics, including 25 events with components that call for conducting tactical logistics. This is not surprising, given that logistics often determine the pace of how far and fast a platoon can move. The critical importance of logistics is one of many reasons the Commandant of the Marine Corps emphasizes energy reduction and self-sufficiency.

Per the METs for a rifle platoon, specifically MET 5, combat service support, tactical logistics involves eight steps:

- Conduct planning
- Request logistics support
- Prepare for combat
- Execute motorized movement
- Conduct casualty evacuation
- Conduct resupply
- Conduct maintenance
- Report logistics status (USMC 2012b, 1st Platoon Tab)

Tactical logistics are conducted so that materials, equipment, and supplies are available to support the mission and the commander's intent. The main logistics functions while operations are underway are resupply of the platoon and casualty evacuation. These functions sustain the platoon's warfighting capability and preserve its end strength.

The two main techniques for resupply are unit distribution and supply-point distribution. In unit distribution, a higher unit delivers replenishment to a predetermined location; in supply-point distribution, the lower unit travels to a central distribution point to draw necessary items. The latter is the usual method by which companies resupply platoons (HQ USMC 1978, 41–42), but in cases where a platoon has dispersed or distributed operations—such as in extended combat patrolling—tactical and logistics conditions may be such that pickup from a central point is impossible, and supplies are therefore delivered by helicopter or fixed-wing aircraft (HQ USMC 1978, 42). Similarly, medical evacuations may require helicopters or vehicles to transport casualties to field hospitals and care centers (HQ USMC 1978, 15). Helicopter and vehicle ambulances

assets are not found at the platoon level, so the platoon is dependent on other units for resupply and medical evacuation support.

E. U.S. MARINE RIFLE PLATOON MODELED IN THE EW12 WAR-GAME

Expeditionary Warrior 2012 (EW12) is a fictional tabletop war-game set in West Africa in 2024. Its purpose was to “identify potential gaps and opportunities” (USMC 2012a, i) in the Marine Corps’ ability to conduct amphibious operations against an enemy with anti-access and area-denial capability. The scenario imagines a joint force intervening in the politically unstable nation of Savanna, which faces invasion from a more powerful neighbor with a conventional army, the West African Federation. Savanna is further destabilized by the Free Savanna Movement (FSM), an irregular indigenous force. U.S. forces are opposed by the most powerful African nation in the region (USMC 2012a, 7).

The main Marine Corps element is a Marine Expeditionary Unit embarked with an amphibious ready group. The MEU traverses three phases in the scenario: achieve access, gain entry, and follow-on operations. The achieve-access phase focuses on neutralizing or destroying the enemy’s anti-access and area-denial capabilities to set the conditions for forcible entry by the battalion landing team. The second phase, gain entry, consists of an amphibious assault, the securing of key terrain, and expanding air- and seaports to allow the smooth flow of follow-on forces. In the third phase, follow-on, the MEU isolates the capital city and helps Savanna’s ability to regain control of the country. An important task in this phase is neutralizing or destroying FSM insurgency forces and keeping them from restricting or closing critical lines of communications (USMC 2012a, 8–10).

The war-game models a Marine Corps rifle platoon, assuming the typical energy consumption of a standard platoon with the force structure and equipment described earlier, which conducts a mission of patrols and counterinsurgency operations in Phase III. Details of the mission are described in Chapter III.

F. USING FUNCTIONAL ANALYSIS TO DOCUMENT THE ENERGY BURDEN

Functional analysis is a systems-engineering process used to allocate functionality, performance, and other requirements of a system by taking the top-level function and decomposing it into sub-functions (International Council on Systems Engineering [INCOSE] 2010, 156). Buede defines a function as a “transformation process that changes inputs into outputs” (Buede 2000, 46). Functions are decomposed to the lowest level necessary to fulfill all functionality and performance requirements of the system. This allows understanding of critical interactions, dependencies, and independencies, both internal and external to the system (Kossiakoff and Sweet 2003, 244–246). Once the functions have been decomposed to the lowest level, they are put into a functional-system architecture to provide a representation of the system and clearly communicate functional interactions (Kossiakoff and Sweet 2003, 248). This architecture models the functional performance of the system and shows informational flows between functions that allow system designers to clearly understand components, configuration items, and critical interactions (Buede 2000, 175).

Functional analysis and functional-system architecture are useful in identifying areas where energy-consuming systems or processes are employed by a rifle platoon. The functional architecture can identify and eliminate redundant capabilities, energy-consumption that is not traced to operational requirements, and areas where new equipment or processes can be inserted for energy savings. Once the architecture is known, energy allocations can be assigned to functions and sub-functions so that a total energy-use requirement can be identified and met by the platoon.

G. SUMMARY

The USMC has evolved into a heavier force requiring more energy, the fruit of the long wars in Iraq and Afghanistan that have left it less expeditionary and more dependent on long supply lines for energy. In 2009, the Commandant of the Marine Corps issued a new expeditionary strategy for the Marine Corps, stating five operational objectives for energy reduction and a goal of reducing consumption from eight gallons of

fuel/Marine/day to four gallons by 2025. This chapter describes the Marine rifle platoon mission, structure, and equipment, with an emphasis on which items consume energy, and provides a brief overview of the Expeditionary Warrior 2012 war-game, used in this research a basis on which to calculate platoon energy use. The chapter concludes with a discussion on functional analysis and how it can be used to identify redundant consumption, energy-consuming requirements, and opportunities to save energy.

THIS PAGE INTENTIONALLY LEFT BLANK

III. METHODOLOGY

Initial research into the literature helped frame this inquiry by suggesting an appropriate scenario from which to calculate energy use. Limitations and assumptions were defined to produce a realistic scenario, along with a methodology to calculate casualty estimates and equipment and aircraft energy expenditures.

A. SCENARIO DESCRIPTION

1. Overview

The Expeditionary Warrior 2012 (EW12) tabletop war-game introduced in Chapter II provided a scenario from which to calculate rifle-platoon energy use. As noted, the setting is the fictional West African country of Savanna. An MEU has been tasked to conduct an amphibious assault and enhance Savanna's ability to control its territory. As described in Chapter II, the scenario contains three phases: achieve access, gain entry, and follow-on operations. Figure 1 depicts the theater of operations.

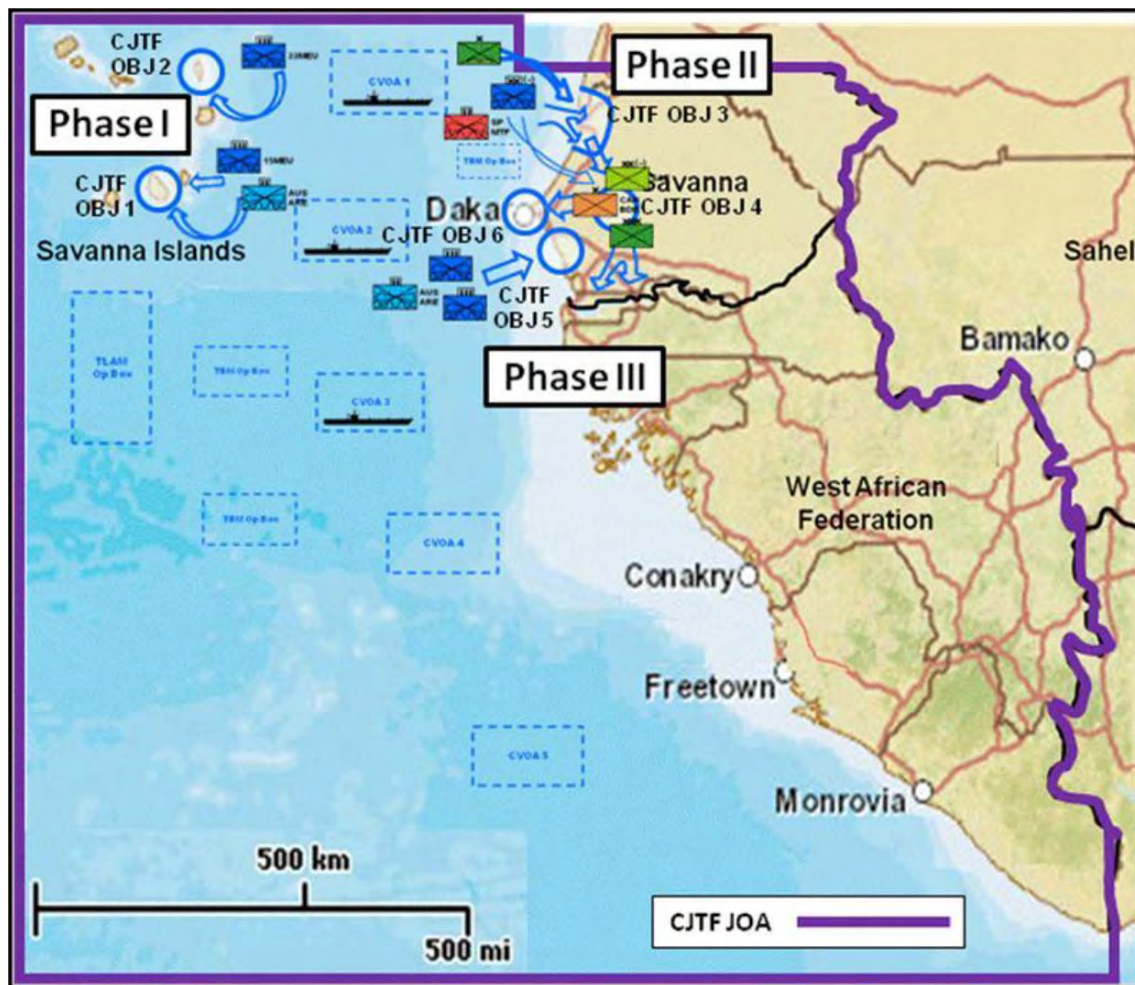


Figure 1. EW12 Concept of Operations
(from USMC 2012a, 9)

The year is 2024. The United States' ally state of Savanna has been invaded by its WAF neighbor, who is supported by Volta, a West African regional power and enemy of the U.S. and coalition partners. Meanwhile, an internal insurgency organization, the Free Savanna Movement (FSM), is using terrorism to overthrow the government. The United Nations Security Council has passed a resolution authorizing a U.S.-led coalition to reestablish Savanna's territorial integrity (USMC 2012a, 6–7). The coalition joint task force (CJTF)–Savanna mission statement reads as follows:

When directed, CJTF–Savanna will conduct Operation RESTORE SOVEREIGNTY to reestablish the territorial integrity of Savanna, neutralize WAF's offensive capability and transition security responsibilities to U.N. forces. (USMC 2012a, 7)

The terrain in Savanna is very complex for a landing force, characterized by poor infrastructure, many rivers, and highly populated coastlines that contain most of the population centers. Approximately 600 kilometers to the west are the Savanna Islands, potentially available to the MEU as air- and sea point of debarkation (APODs/SPODs) (USMC 2012a, 7).

2. U.S. Marine Rifle Platoon Situation and Mission

To capture the U.S. Marine Rifle Platoon's energy use, the third phase of the scenario, follow-on operations, was studied. The platoon's mission is to conduct counterinsurgency operations in an 80-kilometer by 100-kilometer area between CJTF Objective 3 and CJTF Objective 4. The platoon's primary task is to field patrol squads to locate and destroy enemy insurgents within the platoon area of responsibility. The long lines of communication between the sea point of debarkation (CJTF Objective 3) and the city of Dakar are vulnerable to insurgent attacks. Disruption of the supply chain and logistics requirements will compromise the MEU's ability to support the lead echelon elements.

3. Planning Factors

The difficulty in calculating the rifle platoon's energy under the EW12 scenario was in determining the platoon's specific mission, given the vast variability in potential missions and since only the MEU's mission is defined in the war-game. A counterinsurgency mission was chosen as a likely assignment with well-defined parameters from which to calculate energy use. Since rifle platoons carry few energy-consuming devices, the study was expanded to include the transportation assets needed to sustain them.

In his 2005 thesis, "Supporting A Marine Corps Distributed Operations Platoon: A Quantitative Analysis," Matthew D. Bain investigates how many supplies a rifle platoon takes and how often it needs to be replenished in a real-life scenario. Using the planning factors from "A Logistician's Reference," Bain calculated the weight and space required for a day of supply (DOS) for the platoon. Table 3 presents weight and cubic feet per Marine and how much additional weight and capacity is required at the staging

place or in a delivery vehicle. The additional supplies carried by each Marine are extra water and ammunition. Water is assumed at eight additional gallons the first day and 16 each additional day (Bain 2005, 71). These figures are used to determine the airlift support needed to sustain the platoon. Weight is listed in pounds, and volume in cubic feet.

DOS	Weight/ Marine	Cube/ Marine	Additional Weight	Additional Cube	Weight/ Platoon	Cube/ Platoon
1	66	2	310	7	6,320	151
2	79	3	469	10	8,648	225
3	92	3	628	14	10,977	300
4	106	4	787	17	13,305	374
5	119	5	946	20	15,633	448

Table 3. Weight and Days of Supply for Platoon Operations
(from Bain 2005)

B. USMC EQUIPMENT MODELED

The USMC rifle-platoon table of organization does not allocate vehicles, which are reserved for company and higher units. Nor does the platoon carry several common communication, navigation, and targeting systems that use a variety of batteries.

Aviation assets support the platoon by providing lift, aviation-logistics support, medical evacuation and assault-support escort. Assets available to the platoon via the MEU aviation combat element are the MV-22 Osprey, the CH-53E Super Stallion, the KC-130J Hercules and the AH-1W Cobra attack helicopter. These aircraft have differing ranges, speeds, and capacities, as well as rates of energy consumption, and present the greatest opportunity to reduce energy consumption.

Table 4 shows the fuel consumption of Marine Corps aircraft used for assault support. Though the CH-53K and the KC-130J require the most fuel per 100km, they have greater carrying capacity and may thus require fewer flights.

Aircraft	Mission Radius (km)	Max Cruise Speed (km/h)	Gallons per hour	Gallons per 100km	Max Cargo at 4,000 ft, 95 deg F (lb)	Max Cube (ft)
CH-53E	2077	278	589	211.9	17,004	1330
MV-22	1111.2	443	441	99.5	9943	650
KC-130	3800	540	854	158.1	45,000	3622
AH-1W	587	281.5	183	65.0	N/A	N/A

Table 4. Marine Aircraft Comparison
(from Department of Defense 2006)

C. PLANNING ASSUMPTIONS

In building the model, a few assumptions were made regarding operational tempo and the location of supporting units. First, the platoon will remain in place two weeks before being relieved, to experience the operating environment long enough to gain familiarity while ensuring proper rest, recovery, and preparation for follow-on missions. Most logistical supplies will be located at CJTF Objective 3 (SPOD), which is 100 kilometers from the platoon's resupply point. The helicopters are located at CJTF Objective 3, but the C-130 aircraft will come from the APOD, 600 kilometers away on the Savanna Islands. Helicopter assets are located at the SPOD, and the hospital for medical evacuations is on amphibious vessels located approximately 300 kilometers offshore. The final assumption is that during helicopter or tilt-rotor resupply missions, two AH-1 Super Cobra attack helicopters are required for escort and security.

D. THE ENERGY MODEL

The platoon energy model identifies categories that contribute to energy demands, starting with communication, navigation, and targeting systems. Power is primarily supplied in batteries, since the platoon is foot-mobile and independent of vehicles. The second part of the model captures the aviation-fuel requirements for transporting the platoon, providing medical evacuation, and meeting sustainment demands. The aim is to

derive as closely as possible the energy consumption of a 14-day operation, to see where reductions might be made.

1. Battery Model

To discover the number of batteries required by the platoon in the 14-day mission, rifle company equipment allocated to the platoon was identified. The energy consumption values of those pieces of equipment were then calculated to get the total requirement for the platoon.

a. USMC Rifle Company Table of Organization and Equipment

As described in the previous chapter, the rifle platoon is subordinate to the Marine rifle company. The rifle company's primary task is to deploy its subordinate units, the rifle and weapons platoons, and plan and coordinate operations across the full spectrum of expeditionary operations.

Critical to mission operations is good organization and equipment. The rifle company is organized and equipped along five complementary lines: command and control, firepower, mobility, communications, and intelligence, and allocates equipment to the rifle platoons for command and control, firepower, and communications. The rifle company maintains no organic supply support, transportation assets, combat-engineering assets, or health and food services. The company, and therefore its subordinate platoons, is dependent on outside units for these needs.

The rifle company is the lowest level with a table of organization and equipment (TO&E) as provided by the USMC. No formal TO&E is established for platoons—their equipment is allocated from the company. The company's TO&E records two critical sources of information: first, the company's authorized billets and manpower structure, the second, its authorized table of equipment.

The TO&E organizational tables list the billet identification code, rank, military-occupational specialties, and other fields that provide the information needed for manpower officials to staff the company. The list of billets is subdivided into the company's units so that it is easily apparent how many officers and enlisted personnel are

rated in company headquarters, the weapons platoon, and the three rifle platoons. Per the TO&E, the rifle platoon rates one officer and 40 enlisted personnel. The company total is six officers and 176 enlisted (see Table 5).

The second source of information used by manpower officials is the equipment organization for the company, as shown in Table 6. The equipment-organization table identifies what equipment and quantities are rated at the company level. This includes the table-of-allowance material-control number (TAMCN), equipment unique identifiers, equipment nomenclature, and allowances, including future allocations. Unlike billet organization, equipment organization does not include breakdowns of equipment allocation for subordinate company units.

Billet Organization																															
M12163 - RFL CO A, 1/6 2D MARDIV																															
Rec CD	BIC	Billet Description	Alpha Grade	BMO5 ASD1 ASD2	P M O S	B R N	T Y P	S M A R	Res Typ	W F C	Billet SPN	CHARGEABLE				NON-CHARGEABLE										Mapped		A S R	IHVCA	M C C	F T N
												Marine Active Off	Marine Reserve Off	Civ Off	Other Active Off	Other Reserve Off	Marine Active Off	Marine Reserve Off	Civ Off	Other Active Off	Other Reserve Off	MT/MF	UC								
E	M1216300114	RIFLEMAN	PVT	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
D	M1216300115	3D RIFLE SQUAD, 1ST PLATOON																													
E	M1216300116	SQUAD LEADER	SGT	0311	0311	M	E	A	A	U	C	1																1	A-M415	V16	
D	M1216300117	FIRE TEAM 1																													
E	M1216300118	FIRE TEAM LEADER/GRENADIER	CPL	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
E	M1216300119	SQUAD AUTOMATIC RIFLEMAN	LCPL	0311	0311	M	E	A	A	U	R	1																1	A-M415	V16	
E	M1216300120	ASSISTANT AUTOMATIC RIFLEMAN	LCPL	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
E	M1216300121	RIFLEMAN	PVT	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
D	M1216300122	FIRE TEAM 2																													
E	M1216300123	FIRE TEAM LEADER/GRENADIER	CPL	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
E	M1216300124	SQUAD AUTOMATIC RIFLEMAN	LCPL	0311	0311	M	E	A	A	U	R	1																1	A-M415	V16	
E	M1216300125	ASSISTANT AUTOMATIC RIFLEMAN	LCPL	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
E	M1216300126	RIFLEMAN	PVT	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
D	M1216300127	FIRE TEAM 3																													
E	M1216300128	FIRE TEAM LEADER/GRENADIER	CPL	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
E	M1216300129	SQUAD AUTOMATIC RIFLEMAN	LCPL	0311	0311	M	E	A	A	U	R	1																1	A-M415	V16	
E	M1216300130	ASSISTANT AUTOMATIC RIFLEMAN	LCPL	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
E	M1216300131	RIFLEMAN	PVT	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
Section Total D - 1ST PLATOON												1	40																		
C	M1216300132	2D PLATOON																													
C	M1216300245	PLATOON HEADQUARTERS																													
E	M1216300133	PLATOON COMMANDER	1STLT	0302	0302	M	O	A	A	S	C	1																1	A-M415	V16	
E	M1216300134	PLATOON SERGEANT	SSGT	0369	0369	M	E	A	A	U	C	1																1	A-M415	V16	
D	M1216300137	1ST RIFLE SQUAD, 2D PLATOON																													
E	M1216300138	SQUAD LEADER	SGT	0311	0311	M	E	A	A	U	C	1																1	A-M415	V16	
D	M1216300139	FIRE TEAM 1																													
E	M1216300140	FIRE TEAM LEADER/GRENADIER	CPL	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
E	M1216300141	SQUAD AUTOMATIC RIFLEMAN	LCPL	0311	0311	M	E	A	A	U	R	1																1	A-M415	V16	
E	M1216300143	ASSISTANT AUTOMATIC RIFLEMAN	LCPL	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
E	M1216300142	RIFLEMAN	PVT	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
D	M1216300144	FIRE TEAM 2																													
E	M1216300145	FIRE TEAM LEADER/GRENADIER	CPL	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
E	M1216300146	SQUAD AUTOMATIC RIFLEMAN	LCPL	0311	0311	M	E	A	A	U	R	1																1	A-M415	V16	
E	M1216300147	ASSISTANT AUTOMATIC RIFLEMAN	LCPL	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
E	M1216300148	RIFLEMAN	PVT	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
D	M1216300149	FIRE TEAM 3																													
E	M1216300150	FIRE TEAM LEADER/GRENADIER	CPL	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
E	M1216300151	SQUAD AUTOMATIC RIFLEMAN	LCPL	0311	0311	M	E	A	A	U	R	1																1	A-M415	V16	
E	M1216300152	ASSISTANT AUTOMATIC RIFLEMAN	LCPL	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
E	M1216300153	RIFLEMAN	PVT	0311	0311	M	E	A	A	U	M	1																1	A-M415	V16	
D	M1216300154	2D RIFLE SQUAD, 2D PLATOON																													
E	M1216300155	SQUAD LEADER	SGT	0311	0311	M	E	A	A	U	C	1																1	A-M415	V16	

Jun 19, 2013

- 10 -

6:59:12 PM

Jun 19, 2013

- 10 -

6:59:12 PM

Table 5. Billet Organization of a Marine Rifle Company (from USMC 2013b, 10)

Equipment Organization
M2163 - RFL CO A 1st Bn MARCV

TAMCN	Nomenclature (Name - Model)	TAM Stat	U/I	Qty	Rel A/P	Ind Qty	Org Qty	Unit T/E	Current Year Allowance	Fiscal Year												Associated Items		K-7g									
										2013			2014			2015			2016			2017			2018			2019			Association - TAMCN - Nomenclature		
										Start Qty	LT Qty	End Qty	Start Qty	LT Qty	End Qty	Start Qty	LT Qty	End Qty	Start Qty	LT Qty	End Qty	Start Qty	LT Qty		End Qty	Start Qty	LT Qty	End Qty					
																															Used By	D500076	CARRIER/CARGO M2067
A01007G	RADIO SET - AN/PRC-1530(V)	D	SA	N				176	176	176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Used With	H00102E	HEADSET/ELECTRICAL - K-05000
																														Used With	A75177G	TEST SET/RADIO - AN/USM-710A	
A01207G	MULTI-BAND FREQUENCY - AN/PRC-1000(V)	D	SA	R				1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Used By	D00407F	MINE RESISTANT V - CRAP
																														Used With	A75177G	TEST SET/RADIO - AN/USM-71	
																														Used By	D00277F	MINE RESISTANT V - CAT I AT D	
																														Used By	D00257F	MINE RESISTANT V - CAT I AT D	
																														Replacement For	A21647CA	RADIO SET - AN/VRC-1(V)	
																														Replacement For	A21647G	RADIO SET - AN/VRC-1(V)	
																														Used By	D00237F	MINE RESISTANT V - COUGAR C7 I AM	
																														Used By	D500076	CARRIER/CARGO M2067	
A01207G	RECEIVER-TRANSMITTER - AN/PRC-1530(V)	D	SA	R				34	34	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Used With	A00977G	RADIO SET - AN/PRC-110
																														Used By	H00102E	HEADSET/ELECTRICAL - K-05000	
																														Used With	A01057G	RADIO SET - AN/PRC-112	
																														Replaced By	A04077G	WIDEBAND TACTICAL HAND HELD RADIO	
A01007G	RADIO SET - AN/PRC-117(V)	D	SA	R				4	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	Used By	A00517G	REMOTE CONTROL RADI - OR-400-PRC
																														Used By	H00102G	ADAPTOR/POWER SUPPLY - M0000-1	
																														Used With	H00212G	RF-201-A0001 TACTICAL VHF HIGH/LRP OMNIDIRECTIONAL ANTENNA	
A00527G	RADIO SET - AN/PRC-114(V)	D	SA	R				1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	Used By	A00517G	REMOTE CONTROL RADI - OR-400-PRC
																														Used With	H00212G	RF-201-A0001 TACTICAL VHF HIGH/LRP OMNIDIRECTIONAL ANTENNA	

Jun 18, 2019

- 19 -

6:58:12 PM

Table 6. Equipment Organization of a Marine Rifle Company (from USMC 2013b, 19)

b. E2O MEB 2024 Equipment Calculations

The second piece of the battery model is energy calculations for each piece of equipment. For the EW12, the E2O developed an Excel spreadsheet containing each piece of equipment used by a notional Marine Expeditionary Brigade. Providing the energy requirements and consumption rates for vehicles, electrical equipment, and batteries, the E2O spreadsheet provides comprehensive data for each piece of equipment used by elements of the MEB.

c. Building the Battery Model

The company's table of equipment and the energy-requirements list were analyzed and screened for any equipment that consumes energy. Those items of equipment were copied to an Excel spreadsheet listing the TAMCN, nomenclature, and number of items in the company. The spreadsheet was then presented to an infantry officer with extensive experience in company and platoon operations, who identified which items were allocated to rifle platoons and in what quantities—24 items of equipment were highlighted. Next the spreadsheet was populated with relevant data fields from E2O, including battery nomenclature, quantity, and type, computed or advertised runtime, and hours used per day. Three final columns were added for total batteries used per day on a systems basis, by an entire platoon, and during the 14-day mission.

2. Fuel Model

To discover the quantity of aviation fuel used by the platoon in the 14-day mission, four factors were identified as required calculations: the flight to the area of responsibility (AOR), sustainment flights, medical-evacuation missions, and the flight from the AOR to the company's rear area. Combining the fuel consumption for each step provided a total calculation for comparison purposes.

a. Step 1: The Flight to MRP AOR

For flights to the platoon's area of responsibility, two aircraft are available: the MV-22 and the CH-53E. The MV-22 can carry a maximum of 24 combat Marines (Boeing Fact Sheet, 2) and the CH-53E can carry 37 without the center-row seats (Naval

Technology n.d.). Therefore, two aircraft are needed to move the platoon in either case, both with two AH-1W escorts. Since the starting point is the SPOD, determined to be 100 kilometers away, and the maximum speed of the AH-1W is 281.5 kilometers per hour, the round trip for both aircraft types is calculated as requiring 1.42 hours of flight. This total time, multiplied by gallons per hour, provides the total fuel consumed by each asset and is used to calculate which option saves fuel.

b. Step 2: Sustainment Flights

For sustainment flights, the options are the MV-22, the CH-53E, or the KC-130. For replenishment, two MV-22s are required, with one CH-53E or KC-130. The MV-22s and CH-53Es originate from the SDOD and require an AH-1W escort. The KC-130 would use aerial delivery, since landing in the platoon's AOR would be unlikely, and thus an escort would not be required. The total number of sustainment trips to resupply the platoon every two days is six: $14 \text{ (total mission days)} / 2 \text{ (days between resupply)}$ less one (accounting for the return trip).

c. Step 3: MEDEVAC Missions

A casualty-rate estimate is required to calculate the requirements for medical-evacuation missions and associated energy needs. Since only the platoon and aircraft are involved, the casualty estimate accounts for ground and aviation combat only. Estimation is a four-step process using Part IV of the *MEF Planner's Reference Manual*, "Staff Planning Factors and Considerations" (HQ USMC 1999). These steps include determining the combat-intensity level and estimating the casualty range for the platoon, the total aviation-combat casualties for both troop lift and resupply missions, and the total.

The METT-matrix provides the data necessary to assess combat-intensity level, based on mission, enemy strength, terrain, and troops available. Employing our knowledge of the operating area from the EW12, there is a moderate degree of risk to mission accomplishment (a score of 15); the enemy may be capable of delaying mission accomplishment (a score of 14); the terrain is relatively clear, with natural obstacles (a score of 5); and less than a third of the platoon is expected to engage the enemy in

combat (a score of 8). The total score of 42 indicates an intensity level of moderate combat, as shown in Table 7.

Mission Score	<u>15</u>		
Enemy Score	<u>14</u>		
Terrain Score	<u>5</u>		
Troops Score	<u>8</u>		
Total Score	<u>42</u>		
		Intensity Level	Moderate

Table 7. Combat Intensity for the Rifle Platoon's EW12 Mission

The next task is to estimate the casualty range, matching the intensity score to the low, average, and high-scoring values on the chart. The moderate-combat score ranges from 37–53, with 45 the middle value. Forty-two lies closer to the mid value, versus the low value (37). Matching moderate combat to the average column, we get an estimated 4.4 casualties per thousand per day (see Table 8).

Casualties per Thousand per Day			
Intensity	Low	Average/Mid	High
Light	1.03	1.98	2.93
Moderate	2.94	4.4	5.86
Heavy	2.94	8.37	10.86
Intense	10.87	14.05	17.22
<div> <div>Low</div> <div>Ave/Mid</div> <div>High</div> </div> <div> <div></div> <div><u>4.4</u></div> <div></div> </div>			

Table 8. Estimate Casualty Range for Ground Forces

For the 14-day mission, the rifle platoon is expected to take about 2.5 casualties, or three MEDEVAC flights.

An aviation-combat intensity assessment is required to calculate aviation-combat casualties. Like the ground component, it can be assessed as intense, heavy, moderate, or light. “Moderate” corresponds best to the threat environment, as the enemy uses anti-aircraft systems against USMC aircraft. Because our scenario is concerned with troop lift and resupply missions only, we estimate those two mission types using the moderate values.

Casualties per Sortie				
	Combat Intensity Level			
Mission Category	Intense	Heavy	Moderate	Light
Close Air Support	0.04	0.03	0.02	0.01
Deep Air Support	0.18	0.12	0.07	0.02
Troop Lift	0.4	0.28	0.17	0.06
Resupply	0.12	0.08	0.05	0.02
Enter Casualties per Sortie Rates Below				
Close Air Support			0.02	
Deep Air Support			0.07	
Troop Lift			0.17	
Resupply			0.05	

Table 9. Casualties per Sortie

A	B		C		D
Mission Category	Casualty Rate		Sorties per Day		Totals
Close Air Support	0.02	x	0	=	0
Deep Air Support	0.07	x	0	=	0
Troop Lift	0.17	x	0.57	=	0.1
Resupply (every 2 days)	0.05	x	24	=	1.2
Total Aviation Casualties					= 1.3

Table 10. Total Aviation Casualties

Adding the ground-casualty estimate to the aviation for resupplies happening every two days, we get an estimated total casualty figure of 3.8. This requires four medical evacuation flights.

From here, there is the option of using MV-22s, unescorted or escorted, or CH-53Es, unescorted or escorted. With this information, we calculate the total energy required for medical evacuation.

d. Step 4: Flight from AOR

The fourth step repeats step one, since it is the return flight home. This calculation accounts for a single platoon alone, and not a replacement platoon flying in to relieve the departing platoon—its view is limited to the 14 days. If follow-on missions were to occur, the fuel would be shared between the two flights, yielding savings.

E. SUMMARY

This chapter used a scenario in Expeditionary Warfare 2012 to establish parameters by which energy usage of a rifle platoon can be analyzed for potential energy savings. The following chapter analyzes model outputs to offer conclusions and recommendations.

IV. DATA ANALYSIS

This chapter contains the outputs of the energy model described in the Chapter III to determine where potential energy savings may be achieved at the platoon level. The battery model looks at 21 energy-consuming items of equipment used by the platoon, and calculates the number of required batteries per device and batteries consumed in a 14-day period. Next, outputs from the fuel model, which calculates total fuel required using different aircraft type/model/series and sustainment intervals, are presented and analyzed.

A. BATTERY MODEL DATA PRESENTATION

The batteries for the 21 pieces of equipment used by the platoon were entered into the Expeditionary Energy Organization's spreadsheet, so that total number of batteries used could be calculated. Battery type, total quantity used by the system, computed or advertised runtime, power data source, and numbers of hours the equipment is used during the Expeditionary Warrior 2012 war-game were entered into the spreadsheet. Three extra columns were included—batteries/day/system; batteries/day/MRP and batteries/14-day mission—to record the total number of non-rechargeable batteries used by the platoon. Some systems use more than one battery type; in those cases, an average was calculated. A fourth column was reserved for number of battery recharges. If a battery had insufficient life to last two days, it was assumed to need charging once a day.

Table 11 shows the total required batteries per system and for the platoon. During a 14-day mission, a platoon requires over 13,500 single-use batteries, has to charge the rechargeable batteries 775 times, and must carry ten kinds of batteries. Of the 13,500 non-rechargeable batteries, the two systems with highest use are flashlights, such as that pictured in Figure 2, at over 8,000 batteries, and infrared-illumination devices (NVGs, Figure 2), at over 4,000 batteries. Both devices are fielded to each member of the platoon. The model assumes the flashlight will be used 14 hours a day and its two batteries will last two hours. Using the flashlight judiciously and maintaining light discipline significantly reduces consumption, to the point that no batteries will require changing. For the NVGs, the model assumes 14 hours of daily usage for the two batteries will last for four hours.

TAMCN	Nomenclature	Number/ Number/	Number/ MRP	Battery Nomenclature	Battery Qty	Hours used/ day	Batts/ Day/Sys	Batts/ Day/ MRP	Batts/ 14- day mission	Average	Average Charges
A01187G	RADIO SET - AN/PRC-153(V)1	176	40	BATTERY, RECHARGEABLE, LITHIUM IO	1	6	0.740741	29.62963	414.8148		560
A01297G	RECEIVER-TRANSMITTE - AN/PRC-152(V)1(C	34	6	BATTERY, RECHARGEABLE, LITHIUM	1	6*	0.612245	3.673469	51.42857		84
A12607G	RECEIVER,RADIO NAVI - AN/PSN-13(B)	6	1	BATTERY, NONRECHARGEABLE, ALKAL	4	6	2.086957	2.086957	29.21739	29.21739	
B04722E	DEMOLITION SET,EXPL	3	1	BATTERY, NONRECHARGEABLE, ALKAL	1	14	1.4	1.4	19.6	19.6	
C00042E	VIEWING SET, INFRARE - NH11	5	1	BATTERY, RECHARGEABLE, NICKEL ME	1	14*	9.333333	9.333333	130.6667		130.6667
C00742E	FLASHLIGHT - 14032	182	41	BATTERY, NON-RECHARGEABLE, ALKA	2	14*	14	574	8036	8036	
E00087G	NIGHT VISION DEVICE - AN/PVS-24A	36	9	BATTERY, NONRECHARGEABLE, LITHIU	1	14*	0.451613	4.064516	56.90323	56.90323	
E00587G	ILLUMINATOR,INFRARE - AN/PEQ-16B	155	41	LITHIUM/MANGANESE DIOXIDE PRIMA	2	14*	7	287	4018	4018	
E09567B	BORELIGHT SYSTEM,LA - LBS-300-A2	15	3	BATTERY, NONRECHARGEABLE, ALKAL	1	14*	1.75	5.25	73.5	73.5	
E11542B	NIGHT VISION DEVICE - AN/PVS14	182	41	BATTERY, NONRECHARGEABLE, ALKAL	1	14	0.466667	19.13333	267.8667	267.8667	
E11607G	NIGHT VISION SIGHT - AN/PVS17C	36	9	BATTERY, NONRECHARGEABLE, ALKAL	1	14	1.75	15.75	220.5	220.5	
E17797B	SIGHT,GRENADE LAUNC - AN/PSQ18A	35	9	BATTERY, NONRECHARGEABLE, ALKAL	1	14*	1.75	15.75	220.5	220.5	
E17987G	ILLUMINATOR,INFRARE - AN/PEQ-15	36	9	BATTERY, NONRECHARGEABLE, ALKAL	2	14	4.307692	38.76923	542.7692	542.7692	
A12607GJ	NAVIGATION SET,SATE - AN/PSN-13(A)	5	1	BATTERY, NONRECHARGEABLE, ALKAL	4	6	2.086957	2.086957	29.21739	29.21739	
E00547GA	RANGE FINDER,LASER - AN/PEQ-13	5	1		2	14*	0.028028	0.028028	0.392392		
					8		9.73913	9.73913	136.3478	71.71341	
					12		5.6	5.6	78.4		
									total	13585.79	774.6667

Table 11. Expeditionary Energy Model Showing Rifle-Platoon Equipment Only



	
FLASHLIGHT—14032	ILLUMINATOR,INFRARED—AN/PEQ-16B
From Amazon, accessed 9/7/14	Morovision.com, accessed 9/7/14

Figure 2. Typical Platoon Flashlight and NVGs

The most common battery used by the platoon is the non-rechargeable alkaline AA, which powers eight different pieces of equipment. If flashlight batteries are removed, the platoon will use over 5,550 non-rechargeable batteries over the 14-day mission. Depending on the time of year and natural light available, the quantity of required batteries could be reduced by a thousand lithium/manganese-dioxide primary batteries by reducing the operating time of the NVGs. Rechargeable batteries are employed in only three pieces of equipment in the platoon—the portable radio set used by every member is the most common. Six AN/PRC-152 radios are used at the platoon level plus one infrared viewing set using a rechargeable nickel–metal-hydride battery.

Most systems use standard, consumable batteries. If they were to use rechargeable batteries, the platoon would become less dependent on consumable batteries, provided the platoon has access to a power source that can recharge a large number simultaneously.

B. FUEL-MODEL DATA PRESENTATION

The model to calculate the fuel required for transportation and sustainment of the Marine rifle platoon was done in four steps, as detailed in Chapter III. The paragraphs below present calculations from the model, with a short analysis for each step.

1. The Flight to the AOR

The two vehicle options for flights to the AOR are the MV-22 or the CH-53E, deploying two of each aircraft for every trip and a two-ship AH-1W escort. The AH-1W is the limiting factor in an MV-22 flight, since the helicopter's maximum cruise speed is 281.5 kilometers per hour. The maximum cruise speeds of the CH-53E and AH-1W are almost equal (only 3.5 kilometers different). Therefore, a round-trip of 200 kilometers for each leg takes 1.4 hours of flight time and consumes fuel as follows:

- MV-22, 441 gallons per hour
- CH-53E, 589 gallons per hour
- AH-1W, 183 gallons per hour

The calculated fuel for these options breaks out as follows:

a. Option 1: MV-22

Flight time: 200 kilometers multiplied by two (for a round-trip), divided by 281.5 (maximum cruise speed), equals 1.42 hours.

Energy required (MV-22): 441 gallons multiplied by 1.42 (flight time), multiplied by two (two MV-22s required), equals 1,253 gallons of fuel required.

Energy required (AH-1W): 183 gallons multiplied by 1.42 (flight time), multiplied by two (two AH-1Ws required), equals 520 gallons of fuel required.

The total fuel required for option one, MV-22s with AH-1W escort, is 1,773 gallons.

b. Option 2: CH-53E

Energy required (CH-53E): 589 gallons, multiplied by 1.42 (flight time), multiplied by two (two CH-53Es required), equals 1,674 gallons of fuel required. The flight time and AH-1W energy requirements are the same for this option as the MV-22, so the total required energy for the CH-53E option is 2,194 gallons of fuel.

c. Analysis

Comparing the options above, the MV-22 is the more fuel efficient, saving 420 gallons of fuel on a round-trip insertion flight. The capacity of the CH-53E is 37 Marines, just three shy of what is needed to transport the platoon in one CH-53E. If the CH-53E capacity could be expanded to carry 40 Marines, it would reduce the CH-53E fuel requirement by 835 gallons. Using only one CH-53 would save 400 gallons of fuel over the two MV-22s.

2. Sustainment Flights of the Platoon

There are three airframe platforms that could provide rifle-platoon logistics supplies: the MV-22, CH-53E, and the KC-130. The previous chapter described the cubes and weights for a platoon's resupply requirements. Three days of supplies would require 92 pounds to be carried per Marine and a resupply interval of every two days. A single MV-22 could not carry the necessary 10,977 pounds of supplies and would require at least two aircraft. The CH-53E would require only one aircraft, as would the KC-130. However, the KC-130 would originate from the APOD, which is 600 kilometers away. The MV-22s and CH-53Es would come from the SPOD, the same location that the insertion flights originated from, and would require an AH-1W escort. The KC-130 would use aerial drops and be high enough to obviate an escort.

Sustaining the platoon with three days of supply every two days would require six trips for the 14-day mission (14 (total mission days) / two (days between resupply)—1 (accounting for the return trip)).

a. Option 1, MV-22

Two MV-22s flying for 1.42 hours, multiplied by six trips, equals 7,520 gallons of fuel. Adding the 3,120 gallons required by the AH-1W, a total quantity of 10,640 is required for this option.

b. Option 2, CH-53E

One CH-53E can carry the necessary supplies for the platoon and would require 5,020 gallons of fuel. Combined with the AH-1W, this would require 6,582 gallons.

c. Option 3, KC-130

The KC-130 would require 2.2 hours of flight time, since its maximum cruise speed is 540 kilometers per hour and the total flight distance is 1200 kilometers. Each flight would require 1,900 gallons of fuel and a total of 11,400 gallons for the six sustainment flights.

d. Analysis

Comparing the three options, the CH-53E is the most fuel efficient for carrying out the sustainment flights. The KC-130 option would never be used to sustain only a single platoon, as its lift and capacity is overkill and expensive. However, if the KC-130 be used to sustain multiple units, the amount of fuel chargeable to the platoon would be much less, and would make this a more attractive option. The CH-53E carrying capacity would allow it to carry three, four, or five days of supply in a single helicopter. If resupplies were delayed to every three days, only 4,388 gallons of fuel would be required, or 3,291 gallons if the platoon is resupplied every four days. This amounts to a savings of 33 percent of the fuel costs by delaying resupply by an additional day (2,194 gallons) or by half if resupply is delayed by two more days (3,291 gallons). Such delays assume that Marines on the ground can carry additional weight, or there is some offset to the size and weight of supplies the Marines are carrying, or the platoon receives a type of equipment that can carry supplies in the field.

3. Medical Evacuation Missions

As described in Chapter III, under the given the threat assessment, the Marine Corps would expect up to four casualties in this 14-day mission, which would require four separate medical evacuation (MEDEVAC) flights. Aircraft available to the Marine expeditionary unit are the MV-22, the CH-53E, and the UH-1Y. These could be sent escorted or unescorted.

a. Option 1, MV-22, Unescorted

An unescorted MV-22 would not be limited to the escort speed of the AH-1W and would be able to make maximal use of its fast 443-kilometers-per-hour cruise speed. The energy required for four round-trip MEDEVAC flights would be 400 kilometers (round-trip flight distance), divided by 443 (maximum cruise speed), multiplied by 441 (gallons per hour), multiplied by four flights. The total gallons of fuel used would be 1,593.

b. Option 2, MV-22, Escorted

If a two-ship AH-1W is required, the total fuel would increase by almost 3,000 gallons over the unescorted option, due to a combination of the MV-22's having to fly a slower speeds and the additional fuel used by the AH-1W.

c. Option 3, CH-53E, Unescorted

An unescorted CH-53E can fly 278 kilometers per hour and would not be limited to the escort speed of the AH-1W. For four round-trip MEDEVAC flights, the formula would be 400 kilometers (round-trip flight distance), divided by 278 (maximum cruise speed), multiplied by 589 (gallons per hour), multiplied by four flights. The total gallons of fuel used would be 3,390.

d. Option 4, CH-53, Escorted

If a two-ship AH-1W is required, the total fuel would increase by almost 2,050 gallons over the unescorted option, due to a combination of the CH-53Es having to fly at slower speeds and the additional fuel used by the AH-1W.

e. Analysis

For MEDEVAC missions, the MV-22 would use less energy flying alone, as compared with flying escorted or the CH-53E option. Use of a UH-1Y would save energy over the MV-22, but as its range is limited to 272 kilometers, it would not be able to fly the 400 kilometers in this scenario. Staging a UH-1Y aircraft at a location closer to the platoon's operational area could enable the use of this aircraft and reduce energy consumed. This change would drive other requirements, such as a force to protect the asset and crew swap-outs, which would require additional energy to perform.

4. The Flight from the AOR

The flight from the AOR is the same as the flight to the AOR. For this, there are two options: the MV-22 or the CH-53E. As before, both require two of each aircraft and an AH-1W escort. The maximum cruise speed of the AH-1W would be the limiting factor. The calculated fuel for this option is:

a. Option 1: MV-22

Total fuel required for option one is 1,773 gallons to insert the rifle platoon using MV-22s and an AH-1W escort.

b. Option 2: CH-53E

The total required energy for the CH-53E option is 2,194 gallons of fuel.

c. Analysis

As described above, the MV-22 is the more fuel-efficient option, saving 420 gallons of fuel on a round-trip insertion flight. The AH-1W limits the MV-22 from flying at maximum cruise speed. Positioning the AH-1Ws for an escort role closer to the landing zone could reduce the amount of fuel required by reducing the number of flight hours on the MV-22. The MEU's AV-8B fixed-wing attack aircraft would allow the MV-22 to operate at maximum cruise speed, but consumes fuel at almost ten times the rate of the AH-1W (USMC 2013a, Equip Data Tab).

C. ANALYSIS

A United States Marine rifle platoon has very few energy-consuming devices. Standardizing single-use batteries for these devices and replacing them with common rechargeable batteries would reduce the number involved and allow easy exchange among items of equipment.

In this simplified scenario of a platoon on a typical mission, most of the energy consumed is spent in moving and supplying the platoon via aircraft. Use of the MV-22 for all but one of the four missions is the most fuel-efficient option available to the Marine expeditionary unit. The exception to MV-22 thrift is sustainment flights, for which the MEU should use the CH-53E. This recommended combination of aircraft requires an estimated 11,095 gallons of fuel.

Platoon support includes moving the platoon to and from the objective area and MEDEVAC. For these missions, the most fuel-efficient aircraft platform should be used. Sustainment missions, however, are constrained by what the Marines can carry on their persons in the field. If the platoon could pack for additional days, fewer sustainment flights would be needed and the fuel requirements would be reduced. One extra day between resupplies would reduce fuel consumption by 2,195 gallons. If resupply is made at five-day intervals, the total fuel required to sustain the platoon would be cut by nearly half.

It may be possible to move the aircraft's originating position closer to the platoon. For example, moving from a 200-kilometer starting point to a 50-kilometer starting point would reduce fuel requirements by a factor of four and allow use of the UH-1Y for MEDEVAC missions, a much more efficient helicopter platform over the CH-53E or MV-22. It is unlikely that an MEU will reposition assets to support one platoon in the field; however, this option should not be discounted if an optimal support location is found that would minimize flight time and allow use of all helicopter platforms.

D. SUMMARY

The war-game model shows two main energy sources for the platoon: batteries and aircraft fuel. Standardizing batteries and substituting rechargeable batteries is shown

as a viable way of saving energy and cargo space. The platoon's fuel requirements are largely driven by its need to be resupplied every three days. Less frequent sustainment flights would decrease the platoon's energy burden.

V. CONCLUSIONS AND RECOMMENDATIONS

This chapter makes conclusions and recommendations based on investigation of the following primary research questions:

- What specific tasks and operational activities, or capabilities are responsible for the USMC rifle-platoon energy burden?
- What is the energy budget?

A. FACTORS RESPONSIBLE FOR THE USMC RIFLE-PLATOON E2W2 BURDEN

The rifle platoon has 12 mission-essential tasks, from command and control to logistics operations. These tasks and operational activities determine the platoon's equipment inventory and energy usage. The platoon carries mainly small-arms weapons and command-and-control equipment powered by batteries, and lacks vehicles or other types of transport. Transportation requirements are fulfilled by other units.

Within a platoon's combat service-support mission's essential tasks, those of executing motorized movement, conducting MEDEVAC, and resupplying are actions that consume energy. Just as they contribute to the energy burden, so also they provide opportunities for energy reduction.

A counterinsurgency scenario was developed for the platoon using the Expeditionary Warrior 2012 war-game and the energy required to transport the platoon to and from the area of responsibility, conduct medical evacuation, and sustain and resupply the platoon was calculated. It was found that by increasing the ability of each Marine to carry his own supplies, the platoon's energy burden may be decreased.

The second mission-essential task that consumes energy is command and control. Radios and communication systems need batteries. Currently, the platoon uses ten different battery types, especially non-rechargeable AA batteries. A second opportunity to rationalize energy use is to develop standardized, rechargeable batteries.

B. THE E2W2 BUDGET FOR THESE TASKS

Sustainment operations for a two-week counterinsurgency operation require about 11,700 gallons of fuel, based on the lowest consumption option. Placing the aircraft closer to the platoon would decrease fuel consumption, but a more practical way to reduce fuel consumption would be to reduce the number of sustainment flights by increasing the each Marine's ability to carry supplies or increasing the platoon's ability to be self-sustaining.

For a 14-day mission, the platoon would need to carry as many as 5,500 single-use batteries and recharge its reusable batteries 775 times. The platoon requires 4,000 lithium/manganese-dioxide batteries, the primary kind used, every 14 days.

C. RECOMMENDATIONS

1. Investigate Robotic Transport

The platoon is limited to three days of supply (DOS) based on what an individual can carry, which requires logistics runs every two to three days. The Marine Corps should study the used of fuel-efficient, robotic alternative platforms to carry supplies while the platoon is patrolling, to reduce the requirement for logistics and sustainment flights.

2. Unmanned, Aerial Systems

The Marine Corps should continue to explore fuel-efficient unmanned aerial systems (UASs) technologies for sustainment flights that reduce reliance on MEU aircraft assets that are of already low density and high demand. If increasing the DOS is impossible, UASs like the Kaman K-MAX, which is already used by the Marine Corps, could deliver supplies at reduced fuel levels. In this scenario, two K-MAX UASs would deliver the required 10,977 pounds of supplies at a fuel consumption of only 83 gallons per hour, and require no escort. This would be a fuel savings of over 6,000 gallons over a CH-53E with AH-1W escort (Kaman K-MAX n.d.).

3. Standardized, Rechargeable Batteries

The Marine Corps should look at developing standardized, rechargeable batteries that can be used in all command-and-control systems and other equipment. Any robotic device fielded to carry supplies should also be able to recharge batteries, thus reducing the burden the platoon has to carry, keeping waste to a minimum, and providing a ready, reliable source of energy.

D. RECOMMENDATIONS FOR FURTHER RESEARCH

More research is needed to reduce MEU vulnerability due to energy dependency. Recommended areas for future study are as follows:

- Use Expeditionary Warrior 2012 to calculate the energy budget at the company level through all phases of the war game.
- Analyze and make recommendations on robotic solutions that might increase DOS at the platoon level.
- Analyze the feasibility and potential of standardizing batteries for Marine Corps equipment.
- Conduct a similar analysis for water use and recommend ways to reduce platoon water requirements through portable purification or other options.

THIS PAGE INTENTIONALLY LEFT BLANK

**APPENDIX. U.S. MARINE CORPS RIFLE PLATOON MISSION
ESSENTIAL TASKS (FROM USMC 2012B, 1ST PLATOON TAB)**

1. Scout Sniper			
Event	Condition	Standard	Event Components
1.1 Employ a Sniper Control Center (SCC)	Given a tactical scenario, SCC location, communications equipment, report formats, and other necessary equipment and personnel.	To direct team operations, collect, process, analyze, and disseminate information from the scout sniper teams and conduct battle tracking procedures.	1. Establish SCC location.
			2. Set up SCC in organized, efficient process.
			3. Maintain effective communications with sniper teams.
			4. Post correct information on status boards and charts.
			5. Brief information updates as needed.
			6. Maintain communication/log and journals.
			7. Advise, process, report/relay, and disseminate information from and to sniper teams.
			8. Coordinate between sniper teams and affected units.
			9. Coordinate use of the SCC with a higher headquarter command post.
			10. Debrief teams.
1.2 Conduct sniper platoon operations	Given a sniper platoon, an operations order, table of equipment, and an area of operations.	To provide surveillance, fires, reports, and precision engagements as required on the objective without	1. Execute departure of friendly lines.

		being compromised.	
			2. Establish security.
			3. Utilize patrolling techniques.
			4. Continuously camouflage.
			5. Navigate to the objective area using patrolling techniques.
			6. Occupy position.
			7. Observe and report.
			8. Execute precision fires as required.
			9. Observe/Adjust supporting arms as required.
			10. Withdraw from position.
			11. Execute re-entry of friendly lines/adjacent unit linkup.
			12. Conduct debrief.
2 Anti-Armor			
2.1 Provide offensive fires	Given an order, and a supported unit scheme of maneuver, while operating in the full range of environmental conditions.	To support the unit's scheme of maneuver.	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Conduct tactical logistics.
			4. Prepare for combat operations.
			5. Plan for diversions.
			6. Conduct movement.
			7. Occupy cold/hot firing positions.
			8. Identify target by precedence.
			9. Engage targets.
			10. Improve positions as necessary.
			11. Execute screening/signal plan.
			12. Determine effects

			on target(s).
			13. Re-engage target(s) as necessary.
			14. Displace units as necessary.
			15. Consolidate.
2.2 Provide defensive fires	Given an order, and a supported unit scheme of maneuver, while operating in the full range of environmental conditions.	To support the unit's scheme of maneuver.	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Conduct tactical logistics.
			4. Prepare for combat operations.
			5. Plan for diversions.
			6. Conduct movement.
			7. Occupy cold/hot firing positions.
			8. Provide continuous observation.
			9. Provide far target location.
			10. Identify target by precedence.
			11. Engage targets.
			12. Improve positions as necessary.
			13. Execute screening/signal plan.
			14. Determine effects on target(s).
			15. Re-engage target(s) as necessary.
			16. Displace units as necessary.
			17. Consolidate.
2.3 Conduct Motorized operation	Given an order, and a supported unit scheme of maneuver, while operating in the full range of environmental conditions.	To support the unit's scheme of maneuver.	1. Prepare for combat operations.
			2. Conduct traveling.

			3. Conduct traveling overwatch.
			4. Conduct bounding overwatch.
			5. Conduct immediate actions.
			6. Conduct down vehicle and recovery operations.
			7. Conduct convoy security/escort.
			8. Conduct link up/passage of lines.
			9. Conduct route reconnaissance.
			10. Conduct screening.
			11. Conduct consolidation.
3 Assault			
3.1 Provide direct fires	Given an order, and a supported unit scheme of maneuver, while operating in the full range of environmental conditions.	To support the unit's scheme of maneuver.	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Conduct tactical logistics.
			4. Prepare for combat operations.
			5. Execute movement.
			6. Occupy firing positions.
			7. Improve positions as necessary.
			8. Execute signal plan.
			9. Engage target(s).
			10. Determine effects on target(s).
			11. Re-engage target(s) as necessary.
			12. Displace units as necessary.
			13. Consolidate.
3.2 Occupy fires positions	Given an order, and a supported units	To provide fires in support of the scheme	1. Maintain security.

	scheme of maneuver.	of maneuver.	
			2. Coordinate moving/stationary unit contingency plans, as necessary.
			3. Recon tentative hot and cold firing positions.
			4. Select firing positions.
			5. Set conditions for occupation.
			6. Move to firing positions.
3.3 Provide mobility	Given an order, a supported unit's scheme of maneuver, an obstacle(s), and breaching materials.	To support the scheme of maneuver.	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Prepare for combat operations.
			4. Conduct movement.
			5. Set conditions for breach.(SOS)
			6. Reduce obstacle. (R)
			7. Assault through obstacle utilizing marked lane. (A)
			8. Support follow-on movement through breached lanes.
			9. Consolidate.
3.4 Provide counter-mobility	Given an order, a supported unit's scheme of maneuver, and obstacle materials.	To support the scheme of maneuver.	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Prepare for combat.
			4. Recon obstacle site.
			5. Select obstacle site.
			6. Secure obstacle site.
			7. Establish obstacle(s).
			8. Consolidate.
4 Command & Control			

4.1 Conduct planning	Given a unit, a mission, and a commander's intent.	To accomplish the mission and meet the commander's intent.	1. Receive HHQ order.
			2. Set timeline.
			3. Conduct estimate of the situation
			4. Determine enemy courses of action.
			5. Form tentative plan.
			6. Issue warning order.
			7. Conduct coordination.
			8. Arrange for reconnaissance. NAVMC 3500.44A 6-18
			9. Conduct reconnaissance.
			10. Complete the plan.
			11. Issue the order.
			12. Prepare for combat.
4.2 Prepare for combat	Given a mission and commanders intent from a warning order or operations order.	To accomplish the mission and meet the commander's intent.	1. Conduct assembly area actions.
			2. Receive and issue orders/update.
			3. Draw logistics.
			4. Prepare equipment/weapons.
			5. Conduct pre-combat checks and inspections.
			6. Conduct rehearsals.
			7. Conduct confirmations briefs.
			8. Conduct weapons function testing if possible.
			9. Conduct communications checks as required.
			10. Following execution, conduct after action review.

			11. Following execution, conduct debrief.
4.3 Integrate enablers	Given a unit, an order, and available supporting or attached enablers.	To accomplish the mission and meet the commander's intent.	1. Conduct assembly area operations.
			2. Conduct planning.
			3. Integrate fires.
			4. Request additional assets that provide a desired capability as needed.
			5. Conduct tactical logistics.
			6. Prepare for combat operations.
4.4 Execute command and control	Given a unit, a mission, and a commander's intent.	STANDARD: To accomplish the mission and meet the commander's intent. NAVMC 3500.44A 6-20	1. Conduct planning.
			2. Establish main effort.
			3. Establish tactical control measures.
			4. Establish signal plan.
			5. Position leaders to best command unit actions.
			6. Prepare for combat.
			7. Track subordinate, higher, adjacent, supporting, and other actions.
			8. Issue frag orders as needed.
			9. Report/provide information to higher, adjacent, supporting, and other units.
			10. Assess the situation.
			11. Prepare for follow on operations.
5 Combat Service Support			
5.1 Conduct tactical	Given a unit, a	To accomplish the	1. Conduct planning.

logistics	mission, and commander's intent, while operating independently or as part of a larger unit.	mission and meet the commander's intent.	
			2. Request logistics support.
			3. Prepare for combat.
			4. Execute motorized movement.
			5. Conduct CASEVAC.
			6. Conduct resupply.
			7. Conduct maintenance.
			8. Report logistics status.
6 Force Protection			
6.1 Conduct Force Protection	CONDITION: Given a unit, a mission, and a commander's intent.	To mitigate risk to friendly forces.	1. Conduct planning.
			2. Determine hazards to the force.
			3. Implement hazard mitigation.
			4. Continually reassess.
6.2 Operate in a CBRNE Threat Environment	Given a unit, an order, and a CBRNE threat.	To accomplish the mission a meet the commander's intent.	1. Conduct planning.
			2. Conduct tactical logistics.
			3. Prepare for combat.
			4. Conduct CBRN-E reporting.
			5. Conduct operations in a contaminated environment.
			6. Conduct decontamination.
			7. Conduct consolidation.
6.3 Operate an entry control point	Given a unit, an order, and a controlled operating base or outpost.	To accomplish the mission and meet the commander's intent and prevent enemy forces from gaining covert or forced entry to the controlled area.	1. Conduct assembly area actions.

		NAVMC 3500.44A 6-23	
			2. Conduct planning.
			3. Integrate fires.
			4. Conduct tactical logistics.
			5. Prepare for combat.
			6. Occupy the entry control point.
			7. Conduct linkup with adjacent forces, as required.
			8. Execute security plan.
			9. Execute priorities of work.
			10. Register fires.
			11. Execute command and control.
			12. Control vehicles and personnel.
			13. Search vehicles and personnel.
			14. Track vehicles and personnel.
			15. Escalate force, as necessary.
			16. Conduct information collections.
			17. Detain personnel.
			18. Conduct tactical casualty care.
			19. Conduct consolidation.
6.4 Operate a traffic control point	Given a unit, an order.	To accomplish the mission and meet the commander's intent.	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Integrate fires.
			4. Conduct tactical logistics.
			5. Prepare for combat.
			6. Depart friendly lines.

			7. Occupy the traffic control point.
			8. Conduct linkup with adjacent forces as required.
			9. Execute security plan.
			10. Execute priorities of work.
			11. Execute command and control.
			12. Control vehicles and personnel.
			13. Search vehicles and personnel.
			14. Track vehicles and personnel.
			15. Escalate force as necessary.
			16. Conduct information collections.
			17. Detain personnel.
			18. Conduct tactical casualty care.
			19. Conduct consolidation.
			20. Remove traffic control point.
			21. Return to friendly lines.
			22. Conduct debrief.
7 Fire Support			
7.1 Integrate fires	Given a unit, an order, a scheme of maneuver, and supporting arms available.	To support the scheme of maneuver.	1. Conduct planning.
			2. Confirm targets/scheduling.
			3. Conduct tactical logistics.
			4. Prep for combat.

			5. Exercise command and control.
			6. Conduct targeting.
			7. Conduct weaponeering.
			8. Deconflict battlespace geometry.
			9. Execute engagement criteria.
			10. Execute target precedence.
			11. Determine effects of fires.
			12. Refine accuracy.
8 Intelligence			
8.1 Conduct information collection	Given an order, intelligence requirements, and equipment.	To provide information relative to the enemy, terrain, and weather that supports the commander's intelligence requirements.	1. Conduct planning.
			2. Disseminate information requirements.
			3. Request non-organic support into the collection effort.
			4. Integrate non-organic support.
			5. Coordinate individual collection efforts into the collection plan.
			6. Integrate intelligence collection priorities into operations.
			7. Conduct tactical site exploitation.
			8. Report information to higher.
			9. Receive intelligence from higher.
			10. Disseminate intelligence.
			11. Refine collection

			efforts.
8.2 Conduct tactical site exploitation	Given an order, and a site.	To obtain information that supports mission accomplishment and commander's intent.	1. Conduct assembly area actions.
			2. Task organize for TSE.
			3. Conduct planning.
			4. Conduct tactical logistics
			5. Prep for combat.
			6. Depart friendly lines.
			7. Maintain security.
			8. Conduct deliberate search of site.
			9. Execute priorities of exploitation.
			10. Detain personnel if necessary.
			11. Conduct tactical questioning.
			12. Document finds including location, sketch/photographs.
			13. Bag finds.
			14. Tag/label finds.
			15. Establish chain of custody.
			16. Transfer finds to higher.
9 Maneuver			
9.1 Conduct a ground attack	Given a unit, attachments, an order, while motorized, mechanized, or dismounted, and operating in the full range of environmental conditions, during daylight and limited visibility.	To accomplish the mission and meet commander's intent.	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Task organize.
			4. Integrate attachments as required.
			5. Integrate fires.

			6. Conduct tactical logistics.
			7. Prep for combat.
			8. Execute command and control.
			9. Cross line of departure.
			10. Breach obstacles as necessary.
			11. Conduct gap crossing if necessary.
			12. Establish support by fire position(s).
			13. Move to assault position.
			14. Dismount if necessary.
			15. Execute actions of the objective.
			16. Consolidate.
9.2 Conduct a movement to contact	Given a unit, attachments, mission, a commander's intent, an area of operations, and an uncertain enemy situation.	To gain and maintain contact, accomplish the mission and meet the commander's intent.	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Task organize.
			4. Integrate attachments as required.
			5. Integrate fires.
			6. Conduct tactical logistics.
			7. Prep for combat.
			8. Execute command and control.
			9. Cross line of departure.
			10. Monitor and adjust movement formations based on estimate of the situation.
			11. Breach obstacles as necessary.
			12. Conduct gap crossing if necessary.
			13. Execute actions

			on contact.
			14. Develop the situation for higher, adjacent, and supporting in accordance with commander's intent.
			15. Consolidate/transition.
9.3 Conduct a helicopter-borne/tiltrotor-borne attack	Given a unit, attachments, an order, and assault support aircraft, and operating in the full range of environmental conditions, during daylight or limited visibility.	To accomplish the mission and meet commander's intent.	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Task organize.
			4. Integrate attachments as required.
			5. Integrate fires.
			6. Conduct tactical logistics.
			7. Prep for combat.
			8. Execute command and control.
			9. Conduct insert.
			10. Move to assault position.
			11. Breach obstacles as necessary.
			12. Conduct gap crossing if necessary.
			13. Establish support by fire position(s).
			14. Execute actions of the objective.
			15. Consolidate.
9.4 Conduct a raid	Given a unit, attachments, a mission and commander's intent while motorized, mechanized, or dismounted with or without assault support.	To accomplish the mission and meet the commander's intent while maintaining accountability of all personnel and equipment.	1. Conduct assembly area actions.

			2. Conduct planning.
			3. Task organize.
			4. Integrate attachments as required.
			5. Integrate fires.
			6. Prep for combat.
			7. Execute command and control.
			8. Move to the objective.
			9. Isolate the objective.
			10. Execute actions on the objective.
			11. Conduct information collection.
			12. Conduct accountability.
			13. Withdrawl.
			14. Conduct post combat actions.
9.5 Integrate Armor	Given a unit, an order, and a supporting or attached tank and/or mechanized unit.	To maximize maneuverability, speed, momentum, firepower, and shock effect to accomplish the mission and meet the commander's intent.	1. Conduct planning.
			2. Integrate fires.
			3. Conduct tactical logistics.
			4. Coordinate communications.
			5. Coordinate visual signal plan.
			6. Conduct prep for combat ensuring tanks included in planning, rehearsals, and all confirmation briefs.
			7. Execute command and control.
			8. Designate targets based on capabilities and limitations.
			9. Deconflict battle

			space geometry.
			10. Provide security for tanks.
9.6 Conduct a position defense	Given a unit, attachments, an order to conduct a deliberate or hasty defense, specified duration of the operation, and an area.	To accomplish the mission and meet commander's intent.	1. Conduct assembly area actions.
			2. Determine appropriate defensive technique.
			3. Conduct planning.
			4. Integrate attachments as required.
			5. Integrate fires.
			6. Conduct tactical logistics.
			7. Prep for combat.
			8. Occupy the defense.
			9. Conduct linkup with adjacent forces as required.
			10. Execute command and control.
			11. Execute security plan.
			12. Execute priorities of work.
			13. Integrate least engaged unit into the defense as necessary.
			14. Execute the scheme of maneuver and fire support plan.
			15. Consolidate.
9.7 Conduct a retrograde	Given a unit, an order, a rear area or amphibious shipping, and an enemy.	To accomplish the mission and meet commander's intent.	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Integrate fires.
			4. Conduct tactical logistics.
			5. Prep for combat.
			6. Execute command

			and control.
			7. Set conditions for retrograde.
			8. Execute the retrograde scheme of maneuver and fire support plan.
			9. Consolidate.
9.8 Conduct assembly areas actions	Given a unit, a mission, and a commander's intent, remote likelihood of enemy contact, and in preparation for follow on operations.	To accomplish the mission, meet the commander's intent, and prepare for follow on operations.	1. Identify tentative positions.
			2. Quartering party/guides conduct reconnaissance of tentative locations.
			3. Conduct movement to designated location.
			4. Guides lead units to assigned sectors/positions.
			5. Maintain and improve all around security (S).
			6. Position automatic weapons on most likely avenues of approach (A).
			7. Improve fields of fire, obstacles, fire support plan, positions/entrenchment (FE)
			8. Conduct planning.
			9. Conduct tactical logistics.
			10. Prep for combat.
9.9 Conduct relief in place	Given a unit, attachments, an order, and while serving as either the relieving or defending unit.	To transition tactical control with minimal disruption to operations and vulnerability to threat actions. NAVMC 3500.44A 6-42	1. Conduct assembly area actions.

			2. Conduct Planning.
			3. Integrate fires.
			4. Prep for combat.
			5. Execute command and control.
			6. Conduct a linkup.
			7. Set conditions for relief in place.
			8. Move to relief positions.
			9. Conduct consolidation as required.
			10. Report status of relief in place to HHQ.
			11. Receive HHQ approval for transfer of tactical control.
			12. Conduct battle handover to relieving unit.
9.10 Conduct a passage of lines	Given a unit, attachments, an order, and while serving as either the moving or stationary unit.	o accomplish the mission, meet the commander's intent, with minimal disruption to operations.	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Integrate fires.
			4. Prep for combat.
			5. Execute command and control. NAVMC 3500.44A 6-43
			6. Conduct a linkup.
			7. Set conditions for passage of lines.
			8. Conduct battle handover with stationary unit.
			9. Move through the passage route(s).
			10. Conduct battle handover to moving unit.
9.11 Conduct a linkup	Given a unit, an order, linkup point(s), and	To linkup with a friendly unit.	1. Conduct planning.

	while serving as either the moving or stationary unit.		
			2. Integrate fires.
			3. Prep for combat.
			4. Execute command and control.
			5. Set conditions for linkup.
			6. Move to contact point.
			7. Moving unit initiates far recognition signal.
			8. Stationary unit responds with far recognition signal.
			9. Stationary unit initiates near recognition signal.
			10. Moving unit responds with near recognition signal.
			11. Coordinate follow-on operations.
9.12 Breach an obstacle	Given a unit, attachments, order, an obstacle that cannot be bypassed, and breaching materials.	To gain mobility through an obstacle and accomplish the mission with minimal delay.	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Integrate fires.
			4. Conduct tactical logistics.
			5. Prep for combat.
			6. Execute command and control.
			7. Set conditions for breach (SOS).
			8. Conduct actions at breach site (R).
			9. Mark cleared lanes.
			10. Maintain near and far side security.
			11. Support follow-on movement through breach lanes.
			12. Continue mission or consolidate as

			necessary.
9.13 Conduct consolidation	Given a unit, a mission, and a commander's intent, and in preparation for follow on operations.	To enable preparation for combat while maintaining security, reorganizing the unit, and improving the current position.	1. Maintain and improve all around security. (S)
			2. Execute command and control.
			3. Displace or reposition elements as required.
			4. Position automatic weapons on most likely avenues of enemy approach. (A)
			5. Process ammunition, casualty, and equipment (ACE) reports.
			6. Redistribute ammunition, personnel, supplies, and equipment.
			7. Conduct tactical casualty care as required.
			8. Detain personnel as required.
			9. Conduct information collections as required.
			10. Improve fields of fire/sectors of fire, obstacles, fire support plan, positions/entrenchment, etc. (FE)
			11. Conduct planning for follow-on operations. NAVMC 3500.44A 6-46
			12. Conduct tactical logistics.
			13. Conduct prep for combat.
9.14 Support by	Given a unit,	STANDARD: To	1. Conduct assembly

fire/overwatch	attachments, an order, and a moving or maneuvering unit/echelon scheme of maneuver; while motorized, mechanized, or dismounted; during daylight or limited visibility.	support maneuver.	area actions.
			2. Conduct planning.
			3. Task organize.
			4. Integrate attachments as required.
			5. Integrate fires.
			6. Conduct tactical logistics.
			7. Prep for combat.
			8. Execute command and control.
			9. Occupy firing/overwatch positions.
			10. Improve positions as necessary.
			11. Execute signal plan.
			12. Determine effects on target(s).
			13. Adjust fires/overwatch as necessary.
			14. Displace as necessary.
			15. Consolidate.
			16. Conduct post combat actions.
9.15 React to a meeting engagement	Given a reinforced rifle platoon, an assigned mission.	The unit reacts to the enemy and the situation based on the commander's intent, maintaining control of all elements and awareness of subordinate and adjacent unit positions and actions.	1. React per developed Standard Operating Procedures (SOPs), rehearsed immediate action drills, or in accordance with commander's intent.
			2. Elements maintain

			awareness of adjacent unit locations.
			3. Determine the enemy's location and disposition.
			4. Forward an initial SITREP.
			5. Conduct an assessment of the situation and issue a verbal fragmentary order that specifies an objective and provides control measures.
			6. Set conditions to support follow on operations.
			7. Consolidate, reorganize, and submit reports per Standard Operating Procedures.
9.16 Conduct a cordon and search	Given a unit, attachments, a mission, commander's intent, a designated location, local populace, and local structures.	To accomplish the mission and meet the commander's intent with minimal collateral damage to the local populace and structures.	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Task organize.
			4. Integrate attachments as required.
			5. Integrate fires.
			6. Prep for combat.
			7. Execute command and control.
			8. Move to the objective.
			9. Establish inner and outer cordon to isolate the objective.
			10. Execute actions of the objective.
			11. Conduct information collection.

			12. Consolidate.
			13. Conduct accountability.
			14. Withdrawl.
			15. Conduct post combat actions.
9.17 Detain personnel	Given a unit, an order, and apprehended personnel.	To ensure safe and expeditious handling of detainees in accordance with the laws of armed conflict. NAVMC 3500.44A 6-51	1. Search detainees for weapons, ammunition, and any other items that may provide potential intelligence value.
			2. Tag detainees.
			3. Photograph scenes of intelligence value.
			4. Inventory all items removed and collect them in a zip loc bag.
			5. Report personnel detained.
			6. Evacuate to a detainee collection point.
			7. Segregate detainees based on perceived status of authority or position.
			8. Safeguard detainees.
9.18 Conduct casualty evacuation	CONDITION: Given a unit, an order, and casualties. NAVMC 3500.44A 6-52	To treat and evacuate casualties in a timely manner with minimal interruption to the mission while maintaining accountability.	1. Establish security.
			2. Provide care under fire if required.
			3. Move casualties to safe area.
			4. Provide tactical casualty care.
			5. Conduct triage.
			6. Coordinate evacuation transport.
			7. Move casualties to transport.

9.19 Employ Scout Snipers	Given scout snipers as an attachment, mission essential equipment and weapons, and a mission.	To support the scheme of maneuver and commander's intent.	1. Conduct planning, coordination, and prepare for combat.
			2. Conduct intelligence preparation.
			3. Establish task and purpose by phase of operation. NAVMC 3500.44A 6-53
			4. Establish information requirements.
			5. Develop the fire support plan.
			6. Designate tactical control measures.
			7. Develop insert and extract plan, if applicable.
			8. Establish quick reaction force/emergency extraction plan.
			9. Conduct movement/actions at specified times, along specified routes, or in designated areas.
			10. Provide priority target list, engagement criteria, and destruction criteria for the snipers' use.
			11. Send and receive required reports.
			12. Ensure readiness to support inserted teams with supporting arms and quick reaction force.
			13. Determine best method to employ snipers in support of current mission

			(protect flanks, provide overwatch, direct fires in support of maneuver, etc.).
			14. Develop a redundant communications plan.
			15. Collect and report required information.
			16. Determine logistical requirements and conduct resupply in a manner that will not compromise the sniper team(s).
			17. Conduct debrief.
9.20 Conduct patrolling operations	Given a unit, attachments, an order, and an area to patrol from, while motorized, mechanized, or dismounted with or without assault support, and operating in the full range of environmental conditions, during daylight and limited visibility.	STANDARD: To accomplish the mission and meet the commander's intent.	1. Conduct planning. NAVMC 3500.44A 6-54
			2. Task organize.
			3. Integrate attachments as required.
			4. Integrate fires.
			5. Conduct tactical logistics.
			6. Prep for combat.
			7. Constitute a quick reaction force (QRF).
			8. Supervise departure of patrols from patrol base.
			9. Conduct actions on the objective.
			10. Execute immediate actions as required.
			11. Conduct tactical

			casualty care as required.
			12. Detain personnel if required.
			13. Conduct information collection/TSE as required.
			14. Conduct re-entry of patrols to patrol base.
			15. Conduct post combat actions.
9.21 Conduct a combat patrol	Given a unit, attachments, a mission and commander's intent.	To accomplish the mission and meet the commander's intent while seeking direct contact.	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Task organize.
			4. Integrate attachments as required.
			5. Integrate fires.
			6. Prep for combat.
			7. Execute command and control.
			8. Conduct a passage of lines.
			9. Move to the objective rally point as necessary.
			10. Execute immediate actions as necessary.
			11. Execute actions of the objective.
			12. Conduct information collection.
			13. Consolidate as necessary.
			14. Return to the objective rally point as necessary.
			15. Re-enter friendly lines.
			16. Conduct post combat actions.

9.22 Conduct a reconnaissance patrol	Given a unit, attachments, a mission and commander's intent.	To gather or confirm information while seeking to avoid direct combat with the enemy. NAVMC 3500.44A 6-57	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Task organize.
			4. Integrate attachments as required.
			5. Integrate fires.
			6. Prep for combat.
			7. Execute command and control.
			8. Conduct a passage of lines.
			9. Move to the objective rally point.
			10. Execute immediate actions as necessary.
			11. Conduct reconnaissance of the objective.
			12. Return to the objective rally point.
			13. Re-enter friendly lines.
			14. Conduct post combat actions.
9.23 Operate from a patrol base	Given a unit, an order, and an area of operations.	To support patrolling operations.	1. Conduct assembly area actions
			2. Conduct planning.
			3. Integrate fires.
			4. Conduct tactical logistics.
			5. Prep for combat.
			6. Move to patrol base.
			7. Execute command and control.
			8. Occupy the patrol base.
			9. Maintain and improve all around

			security (S).
			10. Position automatic weapons on most likely avenues of approach (A).
			11. Improve fields of fire, obstacles, fire support plan, positions/entrenchment (FE).
			12. Conduct continuing actions.
			13. Conduct patrolling operations.
9.24 Retain a cleared area	Given a unit, a mission, commander's intent, and an area cleared of insurgents.	To accomplish the mission and meet the commander's intent with minimum collateral damage to local opinion, personnel, or structures by separating insurgents from the local populace and denying them safe haven.	1. Conduct intelligence preparation of the operating environment (IPOE).
			2. Establish command and control.
			3. Task organize for combined operations with HN security organizations.
			4. Integrate joint, coalition, host nation and interagency capabilities and organizations.
			5. Exchange liaisons with joint, coalition, host nation and interagency organizations.
			6. Provide service and joint capabilities to coalition, interagency and host nation organizations.
			7. Maintain a Civil Military Operations

			Center.
			8. Maintain a persistent intelligence, surveillance and reconnaissance (ISR) capability to develop intelligence on insurgent activity.
			9. Control, direct, coordinate, approve, modify or deny employment of organic and supporting arms.
			10. Conduct combined action where feasible.
			11. Assign combined forces geographic responsibility where feasible.
			12. Transition U.S. positions, checkpoints and responsibilities to combined forces where feasible.
			13. Conduct combined/HN civil military operations.
			14. Transition detention facilities and the conduct of detainee operations.
			15. Kill or capture high value targets.
			16. Transition responsibility for securing lines of communication leading into or out of the cleared area.
			17. Modify population and resource control measures as appropriate.
			18. Conduct targeting of remaining active insurgents.
			19. Target insurgent

			support structures.
			20. Target key individuals and organizations for engagement.
			21. Disrupt insurgents outside of the cleared area. NAVMC 3500.44A 6-60
			22. Conduct the full spectrum of information operations (PSYOP, MILDEC, OPSEC, EW, CNA).
			23. Minimize U.S. presence and promote local HN security organizations.
			24. Assign HN security forces geographic responsibility where feasible.
			25. Transition combined positions, checkpoints and responsibilities to HN forces where feasible.
			26. Provide selective access to coalition enablers.
			27. Transition population and resource control measures to HN authority.
			28. Transition all security responsibilities to HN forces and authority when HN security and governance capacity is proven capable of managing internal threats to stability.
9.25 Train foreign forces	CONDITION: Given a unit, a mission, a	STANDARD: To enhance the	1. Determine method for advising foreign

	commander's intent, and foreign forces.	effectiveness of foreign security forces in conducting operations.	military forces (embedded training team or unit partnership).
			2. Identify personnel and equipment requirements for advisor staff.
			3. Screen advisors.
			4. Provide relevant training to advisors.
			5. Ensure adequate force protection for advisors.
			6. Develop support/ manning/ supply plans in support of advisory team.
			7. Develop plan for information sharing.
			8. Develop campaign plan for military partnering, coordination measures, and transfer of authority as required.
			9. Select and conduct missions and tasks to build successes/ confidence.
			10. Conduct after action reviews.
			11. Identify potential leaders.
10 Machine Guns			
10.1 Provide offensive fire	Given an order, a machinegun unit, a supported unit scheme of maneuver, while operating in the full range of environmental conditions.	STANDARD: To meet commander's intent and to support the unit's scheme of maneuver.	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Conduct tactical logistics.
			4. Prepare for combat operations.

			5. Execute movement.
			6. Occupy firing positions.
			7. Improve positions as necessary.
			8. Issue/receive fire commands.
			9. Execute signal plan.
			10. Determine effects on target(s).
			11. Shift fires as necessary.
			12. Displace units as necessary.
			13. Consolidate.
10.2 Provide defensive fires	Given an order, a machinegun unit, an area to defend, and a supported unit scheme of maneuver, while operating in the full range of environmental conditions.	To meet commander's intent and to support the unit's scheme of maneuver.	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Prepare for combat operations.
			4. Execute movement.
			5. Recon tentative firing positions.
			6. Occupy defensive positions.
			7. Prepare defensive positions.
			8. Issue/receive fire commands.
			9. Execute signal plan.
			10. Engage targets.
			11. Control fires as directed.
			12. Utilize alternate or supplementary positions as necessary.
			13. Prepare for follow on missions.
10.3 Occupy firing	Given an order, and a	To provide fires in	1. Maintain security.

positions	supported units scheme of maneuver.	support of the scheme of maneuver.	
			2. Coordinate moving/stationary unit contingency plans as necessary.
			3. Reconnoiter tentative firing positions.
			4. Select firing position(s).
			5. Set conditions for occupation.
			6. Move to firing positions.
10.4 Conduct Motorized operation	Given an order, a mounted machinegun unit, and a supported unit scheme of maneuver, while operating in the full range of environmental conditions.	To meet commander's intent and to support the unit's scheme of maneuver.	1. Conduct assembly area actions.
			2. Conduct planning.
			3. Issue/receive the order.
			4. Prepare for combat operations.
			5. Screen forward, flank, or rear of a moving unit.
			6. Utilize visual/radio communications.
			7. Maintain all around security.
			8. Execute tactical logistics as required.
			9. Execute contingency plans as required.
			10. React to threats.
			11. Conduct follow-on missions.
11 Mortars			
11.1 Provide indirect fires	Given a mission, a commander's intent, and a supported unit(s) scheme of maneuver,	To support the scheme of maneuver.	1. Conduct assembly area actions.

	while operating in the full range of environmental conditions.		
			2. Conduct planning.
			3. Provide forward observers to the unit as required.
			4. Conduct tactical logistics.
			5. Prepare for combat operations.
			6. Execute movement.
			7. Conduct hip shoot, as necessary.
			8. Occupy firing positions.
			9. Provide local security for the mortar platoon.
			10. Operate split section/platoon, as necessary.
			11. Lay mortars.
			12. Improve positions.
			13. Receive call for fire from supported unit.
			14. Prepare and issue fire commands to the gun line.
			15. Adjust fires as necessary. NAVMC 3500.44A 6-67
			16. Execute signal plan.
			17. Fire standard missions as a section/platoon.
			18. Fire special missions as a section/platoon.
			19. Displace by echelon, as necessary.
			20. Consolidate.
11.2 Occupy a mortar position	Given an order, and a supported unit's scheme of maneuver.	To provide indirect fires in support of the scheme of maneuver.	1. Maintain security

			2. Coordinate moving/ stationary unit contingency plans, as necessary.
			3. Recon tentative firing positions.
			4. Select firing positions.
			5. Set conditions for occupation.
			6. Move to firing positions.
11.3 Fire standard missions as a mortar section/ platoon	Given established firing positions, priorities of fire, a target list worksheet, a target(s), a forward observer(s), and with or without a fire direction center.	STANDARD: To achieve desired effects on target without incurring friendly casualties.	1. Maintain security.
			2. Determine current location.
			3. Determine direction of fire.
			4. Determine referred deflection.
			5. Review priorities of fire.
			6. Review preplanned targets from target list worksheet.
			7. Generate preplanned target firing data.
			8. Issue preplanned priority target fire commands.
			9. Maintain readiness to provide on-call priority fires.
			10. Receive observer location, as necessary.
			11. Receive a call for fire.
			12. Determine target weaponeering.
			13. Transmit message to observer(s).
			14. Compute firing

			data.
			15. Issue fire commands.
			16. Manage ammunition.
			17. Determine observer to target direction, as necessary.
			18. Adjust fire, as necessary.
			19. Fire for effect.
			20. Receive RREMS (refinements, record as target, end of mission, surveillance) from observer.
			21. End fire mission.
11.4 Fire special missions as a mortar section/platoon	Given established firing positions, priorities of fire, a target list worksheet, a target(s), a forward observer(s), and with or without a fire direction center.	To achieve desired effects on target (without incurring/with minimal) friendly casualties.	1. Maintain security
			2. Determine current location.
			3. Determine direction of fire.
			4. Determine referred deflection.
			5. Review priorities of fire.
			6. Review pre-planned targets.
			7. Generate pre-planned target firing data.
			8. Issue pre-planned priority target fire commands.
			9. Maintain readiness to provide on-call priority fires.
			10. Receive observer location, as necessary.
			11. Receive call for

			fire.
			12. Determine friendly positions.
			13. Determine danger close mortar, as necessary.
			14. Determine target weaponeering.
			15. Transmit message to observer.
			16. Compute firing data.
			17. Issue fire commands.
			18. Manage ammunition.
			19. Determine observer to target direction.
			20. Adjust fire by creeping or bracketing, as necessary.
			21. Fire for effect.
			22. Receive RREMS (refine, record as target, end of mission, surveillance) from observer.
			23. End the fire mission.
11.5 Perform reciprocal lay using the mortar sight	Given a declinated compass, boresighted mortars and a mortar position during daylight or darkness.	STANDARD: All guns in the platoon are laid to within one mil.	1. The gun line is laid in the general direction of fire.
			2. One gun is laid using a declinated M2 compass.
			3. Remaining guns are laid per unit SOP using the first gun as the aiming point.
11.6 Lay mortars using a M2 Aiming Circle	Given a declinated M2 Aiming Circle, boresighted mortars and a mortar position during daylight or darkness.	To reduce potential error in mortar gunnery by ensuring all mortars are laid to within one mil.	1. Emplace mortars oriented on the direction of fire post.

			2. Emplace aiming circle.
			3. Perform reciprocal lay off of aiming circle.
			4. Refer and realign each mortar to the referred deflection.
			5. Prepare for fire missions.
11.7 Operate by split platoon	Given a mission that requires fire support of two (2) independent missions or continual fire support for a fast moving attack.	To provide indirect fires that support the unit's scheme of maneuver. NAVMC 3500.44A 6-73	1. Each section moves as an independent element.
			2. Designate firing position for each section that supports supported unit scheme of maneuver.
			3. Status and location of both sections is monitored.
			4. At least one unit can provide indirect fires to the ground unit at all times.
			5. The appropriate section responds to requests for fire according to its mission.
			6. Section Fire Direction Center (FDC) computes data and issues fire commands for their own mortars.
			7. When both sections are supporting the same mission, sections compute their own firing data for fire missions received by the other section.
12 Training			
12.1 Conduct unit readiness planning	Given a units METL, commanders training	To develop combat readiness.	1. Identify collective training standards and

	guidance, commander's training strategy, a battalion long range training plan, and a company mid-range training plan.		individual training standards that support the unit METL/ commanders training strategy.
			2. Conduct platoon training assessment.
			3. Determine training priorities.
			4. Develop a short range training plan.
			5. Publish LOI's. NAVMC 3500.44A 6-74
			6. Develop weekly training schedules.
			7. Coordinate unit training.
			8. Develop materials.
			9. Conduct operational risk assessment.
			10. Conduct training.
			11. Conduct evaluations.
			12. Conduct after-action reviews.

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

- “AH-1W Super Cobra Helicopter,” n.d. US Military About.com accessed May 23, 2014. <http://usmilitary.about.com/library/milinfo/marinefacts/blcobra.htm>
- “AN/PEQ-16 MIPIM.” n.d. Morovision.com. Accessed September 7, 2014. <http://morovision.com/shop/anpeq-16-mipim-mini-integrated-pointing-illumination-module/>
- Babilot, Michael. 2005. “Comparison of a Distributed Operations Force to a Traditional Force in Urban Combat.” Master’s thesis, Naval Postgraduate School, Monterey, CA.
- Bain, Matthew D. 2005. “Supporting a Marine Corps Distributed Operations Platoon: A Quantitative Analysis.” Master’s thesis, Naval Postgraduate School, Monterey, CA.
- “Bell UH-1Y” 2013. Bell Helicopter Textron, Inc. http://www.bellhelicopter.com/en_US/Military/BellUH-1Y/1291148375207.html#/?tab=highlights-tab
- Blanchard, Benjamin S., and Wolter J. Fabrycky. 2011. *Systems Engineering and Analysis*, 5th ed. Upper Saddle River, NJ: Prentice Hall.
- Boeing Backgrounder. 2013, June. “V-22 Osprey,” Boeing Defense, Space & Security, St. Louis, MO. http://www.boeing.com/assets/pdf/rotorcraft/military/v22/docs/V-22_overview.pdf
- Buede, Dennis M. 2000. *The Engineering Design of Systems: Models and Methods*. New York: John Wiley & Sons, Inc.
- Bulanow, Peter, Paul Tabler, and Shawn Charchan. 2011. “Expeditionary Energy Assessment: Environmental Control Unit Alternative Study.” Washington, DC: U. S. Marine Corps Expeditionary Energy Office.
- “CH-53E Super Stallion Heavy-Lift Helicopter, United States of America,” n.d. Naval-technology.com accessed May 23, 2014. <http://www.naval-technology.com/projects/ch53e>
- Chairman of the Joint Chiefs of Staff. 2012. *Manual for the Operation of the Joint Capabilities Integration and Development System*. Washington, DC Chairman of the Joint Chiefs of Staff.
- Department of Defense. 2006. *MIL-STD-1366D: Interface Standard for Transportability Criteria*. Washington, DC: Department of Defense.

- Erwin, Sandra I. 2013. "Army Searches for Its Post-War Identity." *National Defense*. December 1.
- Estes, Kenneth W. 1988. *Marine Corps Officer Guide*. 5th ed. Annapolis, MD: Naval Institute Press.
- Forsberg, Kevin, Hal Mooz, and Howard Cotterman. 2000. *Visualizing Project Management: A Model for Business and Technical Success*. New York: John Wiley & Sons, Inc.
- Grana, Brian T. 2010. "Incentivizing Sustained Department of Defense Energy Efficiency through a Modified Appropriations Framework." Master's thesis, Marine Corps University, Quantico, VA.
- A Guide to the Project Management Body of Knowledge*. 2004. 3rd ed. Project Management Institute. Newtown Square, PA. 2004.
- Hayter, Anthony. 2012. *Probability and Statistics for Engineers and Scientists*. 4th ed. Boston, MA: Brooks/Cole.
- Headquarters U.S. Marine Corps. n.d. *United States Marine Corps Expeditionary Energy Strategy and Implementation Plan*. Washington, DC: The Marine Corps Expeditionary Energy Office, Headquarters U.S. Marine Corps.
- . 1978. *FMFM 6.4 Marine Rifle Company/Platoon*. Washington, DC: Headquarters U.S. Marine Corps.
- . 1998. *MCRP 5-12D, Organization of Marine Corps Forces*. Washington, DC: Headquarters U.S. Marine Corps.
- . 1999. *MSTP Pamphlet 5-0.3 MEF Planner's Reference Manual*. Washington, DC: Headquarters U.S. Marine Corps.
- . 2002. *MCWP 3-11.2 Marine Rifle Squad, with Change 1*. Washington, DC: Headquarters U.S. Marine Corps.
- . 2004. *MCWP 3-24 Assault Support*. Washington, DC: Headquarters U.S. Marine Corps.
- . 2008. *Marine Corps Vision & Strategy 2025*. Washington, DC: Headquarters U.S. Marine Corps.
- . 2010. *Marine Corps Operating Concept 2010*. 3rd ed. Washington, DC: Headquarters U.S. Marine Corps.
- . 2013. *USMC Concepts & Programs 2013*. Washington, DC: Headquarters U.S. Marine Corps.

- International Council on Systems Engineering. 2010. *Systems Engineering Handbook (INCOSE)*. Version 3.2. San Diego, CA: International Council on Systems Engineering.
- “Kaman K-MAX Aerial Truck: Built To Lift.” Kaman Aerospace Helicopters Division. Accessed September 7, 2014. www.kamanaero.com
- “KC-130 Hercules.” n.d. US Military About.com accessed May 23, 2014.
- Kiper, Troy O., Anthony E. Hughley, and Mark R. McClellan. 2010. “Batteries On The Battlefield: Developing a Methodology to Estimate The Fully Burdened Cost of Batteries in the Department of Defense.” Master’s thesis, Naval Postgraduate School, Monterey, CA.
- Kossiakoff, Alexander, and William N. Sweet. 2003. *Systems Engineering Principles and Practice*. New York: John Wiley & Sons, Inc.
- Liker, Jeffery K. 2004. *The Toyota Way: 14 Management Principles from the World’s Greatest Manufacturer*. New York: McGraw-Hill.
- Marine Corps Combat Development Command. 2002. *Marine Rifle Squad*, Marine Corps Warfighting Publication 3-11.2 with Change 1. Quantico, VA: Marine Corps Combat Development Command.
- . 2012. *Initial Capabilities Document For United States Marine Corps Expeditionary Energy, Water and Waste*. Quantico, VA: Marine Corps Combat Development Command.
- Price, Robert R., and Jason A. McHuen. 2009. “Enabling Enhanced Company Operations (ECO): An Analysis of Tactical Communication Requirements and Solutions for a Marine Corps Company and Below.” Master’s thesis, Naval Postgraduate School, Monterey, CA.
- Project Management Institute. 1997. *Principles of Project Management: Collected Handbooks from the Project Management Institute*. Project Management Institute, Sylva, NC.
- Sanders, Todd M. 2005. “Exploring the Effectiveness of the Marine Expeditionary Rifle Squad.” Master’s thesis, Naval Postgraduate School, Monterey, CA.
- Sprincin, Phillip K. S. 2007. “Rethinking the ‘Rifle’ Platoon: Reorganize the Platoon Around Crew-Served Weapons. *Marine Corps Gazette*. <https://www.mca-marines.org/gazette/rethinking-rifle-platoon>
- “Streamlight 14032 Sidewinder Military Tactical Flashlight.” n.d. Amazon. Accessed September 7, 2014. http://ecx.images-amazon.com/images/I/71GfduvFsZL._SL1500_.jpg.

- Strickland, Adam T. 2006. "A Return To The Past In Facing Present-Day Threats," *Marine Corps Gazette*. February.
- Sweetman, Bill. 2013. "Opinion: Navy Struggles Over UAS Stealth Level," *Aviation Week & Space Technology*. December 23.
- Title 10 US Code 5063. 2011.
- United States Marine Corps. 2011. *Integrated Architecture Process and Viewpoint Guide, Version 1.0*. Marine Corps Combat Development Command and Marine Corps Systems Command, Quantico, VA.
- . 2012a. *Expeditionary Warrior 2012; EW12 Final Report*. Quantico, VA: Wargaming Division, Marine Corps Warfighting Laboratory, Marine Corps Combat Development Command.
- . 2012b. "Infantry Readiness Worksheet Template, V16." Excel Spreadsheet. Washington, DC: United States Marine Corps.
- . 2013a. "Expeditionary Energy Office Study Data," Excel Spreadsheet. Washington, DC: Marine Corps Expeditionary Energy Office.
- . 2013b. *Rifle Company A 1/6 2D MARDIV Unit TO&E Report*. Camp Lejeune, NC: Total Force Structure Management System.
- Womack, James P., and Daniel T. Jones. 2003. *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. New York: Free Press.

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
Ft. Belvoir, Virginia
2. Dudley Knox Library
Naval Postgraduate School
Monterey, California